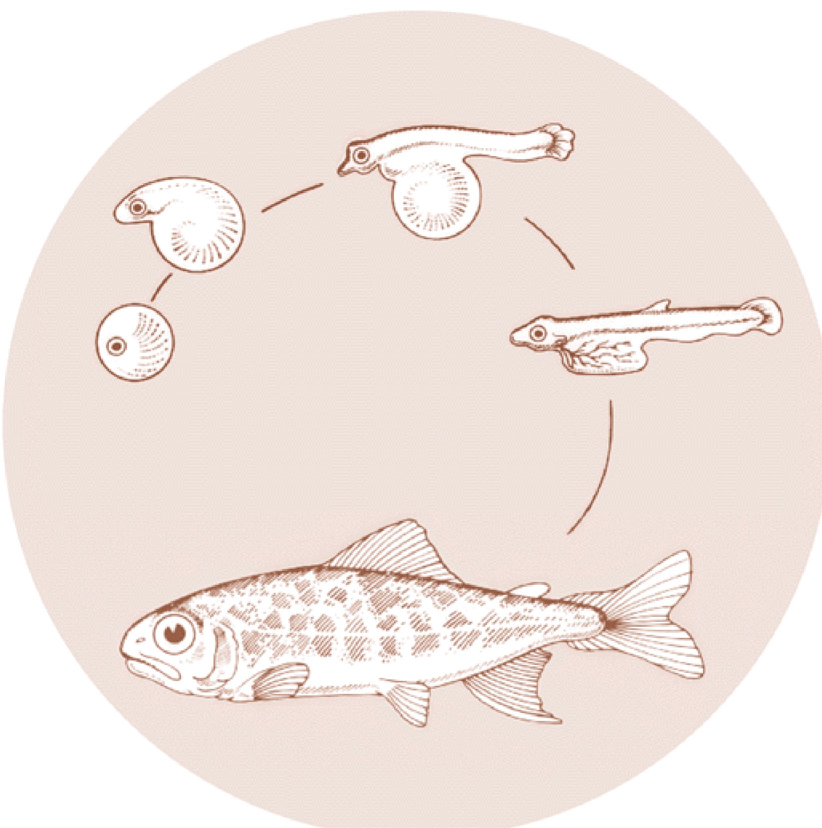
December 1996

IDAHO SUPPLEMENTATION STUDIES

Annual Progress Report

Period Covered: January 1, 1993 to December 31, 1993

Annual Report 1993



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Annual Progress Report
Period Covered: January 1, 1993 to December 31, 1993

Prepared by:

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Project No. 89-098
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December 1996

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ABSTRACT

Idaho Supplementation Studies (ISS) will help determine the utility of supplementation as a potential recovery tool for decimated stocks of spring and summer chinook salmon *Oncorhynchus tshawytscha* in Idaho. The objectives are to: 1) monitor and evaluate the effects of supplementation on presmolt and smolt numbers and spawning escapements of naturally produced salmon; 2) monitor and evaluate changes in natural productivity and genetic composition of target and adjacent populations following supplementation; and 3) determine which supplementation strategies (broodstock and release stage) provide the quickest and highest response in natural production without adverse effects on productivity.

Field work began in 1991 with the collection of baseline data from treatment and some control streams. Full implementation began in 1992 with baseline data collection on treatment and control streams and releases of supplementation fish into several treatment streams. Field methods included snorkeling to estimate chinook salmon parr populations, PIT tagging summer parr to estimate Parr-to-smolt survival, multiple redd counts to estimate spawning escapement and collect carcass information. Screw traps were used to trap and PIT tag outmigrating chinook salmon during the spring and fall outmigration. Weirs were used to trap and enumerate returning adult salmon in select drainages.

Useful findings during the 1993 field season include:

Chinook salmon parr population estimates were calculated two ways - by stream stratification and by habitat type. Estimates were very low in most streams. Error bounds were usually greater than our goal of 30% of the parr estimate. In order to reduce this variability, we will need to increase the sample size, further explore estimates by habitat type, and use distance to redds as a covariate.

Chinook salmon parr population estimates based on habitat have resulted in consistently lower estimates than estimates when habitat types were not partitioned out. They have not resulted in consistently lower confidence intervals.

Habitat surveys have shown where we have gaps or biased sampling in our snorkeling.

Due to the low seeding levels, it was difficult to PIT tag 500 summer parr in all streams. The densities were too low in some streams to warrant tagging.

Our goal of PIT tagging at least 500 spring migrating chinook salmon was reached only in Red River. Delays in permitting resulted in three of the five traps being installed late.

Redd counts have remained low in most cases (ranged from 2 redds in White Sand Creek to 84 redds in Sulphur Creek). The exceptions were the South Fork Salmon River above the weir and American River. Six hundred and ninety-four redds were counted in the South Fork (666 in the South Fork and 28 in Curtis Creek). This was the result of 940 females released above the weir to spawn (100 females trucked to Stolle Meadows and 840 released at the weir). Two hundred and nine redds were counted in American River. Most of these were due to the outplanting of 165 pairs of Rapid River Hatchery chinook salmon adults into American River. Redd counts generally increased over the previous two years.

Our goal of PIT tagging at least 700 fall outmigrants was reached at all the traps except in the Pahsimeroi River. Cold temperatures and a freezing trap in mid-December prevented further trapping.

Trap efficiencies ranged from 1.09% for hatchery smolts and 5.26% for natural smolts in the Pahsimeroi River to 28.16% in Marsh Creek during the spring and from 3.18% for hatchery emigrants and 9.24% for natural emigrants in the Pahsimeroi River to 55.96% Marsh Creek during the fall.

PIT tag detections at the four lower Snake and Columbia River dams for brood year 1991 outmigrants ranged from 1.79% to 15.00% for fish tagged as summer parr, from 1.50% to 24.89% for fall migrants and from 18.00% to 51.61% for spring migrants. Wild/natural fish had higher detection rates than their hatchery counterparts.

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INTRODUCTION

Idaho Supplementation Studies (ISS) was developed to help define the potential role of supplementation in managing Idaho's anadromous fisheries (IDFG 1991) and as a recovery tool for the basin (NPPC 1987, STWG 1988). Research associated with this program will help determine the best broodstock, rearing and release strategies for rebuilding natural populations of chinook salmon *Oncorhynchus tshawyfscha* in various streams, and the effects of these activities on target and non-target natural populations.

Idaho Supplementation Studies are being conducted in two phases. Phase I is completed and includes formation of the Idaho Supplementation Technical Advisory Committee (ISTAC), development of a comprehensive experimental design and database (Bowles and Leitzinger 1991). and initial collection of baseline genetic, physical and biological data.

The experimental design was a cooperative project involving all the members of the ISTAC. The committee is made up of representatives from the U.S. Forest Service (USFS) Intermountain and Northern regions, U.S. Fish and Wildlife Service (USFWS), Nez Perce Tribe (NPT), Shoshone-Bannock Tribes (SBT), Northwest Power Planning Council (NPPC), Bonneville Power Administration (BPA), Idaho Cooperative Fish and Wildlife Research Unit (ICFWRU), and Idaho Department of Fish and Game (IDFG). Their roles were to technically review and provide input on the research design and coordinate with their respective management, research, and user groups. This ensures that long- and short-term management plans of respective agencies and tribes will not compromise the supplementation research design and that management and research concerns of the respective agencies and tribes were represented in the supplementation research design. Through a subcontract with IDFG, the ICFWRU assisted directly in the development of the experimental design, with particular emphasis on the genetic and ecological effects of supplementation on natural populations.

Implementation (Phase II) began in May 1992. The ISTAC will continue technical advisory and agency coordination roles, as well as help insure quality control among cooperators. Responsibilities for implementation and evaluation are currently shared among IDFG, ICFWRU, NPT, SBT, and USFWS. IDFG has taken the lead role in planning and coordination, and will also take the lead in pulling information together as it develops. Each cooperator is responsible for analyzing and reporting annually on their components of the overall Experimental Design. This report represents the second year's results from the IDFG component, and includes: chinook salmon parr population estimates and PIT tagging; emigrant trapping and PIT tagging; spawning escapement estimates; broodstock collections; and spawning, rearing, marking, and releasing supplementation fish. We have also attached the subcontract report for the small scale studies (ICFWRU, Attachment A). IDFG will complete a more comprehensive report in 1996, synthesizing information from all the cooperators collected during the first five years of this study.

The goal of the ISS is to rebuild natural populations of Idaho's chinook salmon to fishable levels (IDFG 1991).

OBJECTIVES

The project objectives are:

1. Monitor and evaluate the effects of supplementation on presmolt and smolt numbers and spawning escapements of naturally produced chinook salmon.

2. Monitor and evaluate changes in natural productivity and genetic composition of target and adjacent populations following supplementation.

3. Determine which supplementation strategies (broodstock and release stage) provide the quickest and highest response in natural production without adverse effects on productivity.

4. Develop supplementation recommendations.

In Idaho, we have the opportunity to address several questions associated with two unknowns: "Can supplementation work?" and "What supplementation strategies work best?" These specific questions are:

1. Does supplementation of existing chinook salmon populations in Idaho enhance natural production?

2. Does supplementation with existing hatchery stocks establish natural populations of chinook salmon in areas of Idaho where chinook salmon were extirpated?

3. Does supplementation of existing chinook salmon populations in Idaho reduce natural productivity of target or adjacent populations below acceptable levels (e.g. replacement)?

4. How often is supplementation required to maintain populations at satisfactory levels?

5. Can existing hatcheries and broodstocks be used effectively to supplement target populations within local or adjacent subbasins?

6. Is there an advantage to developing new, localized broodstocks with a known natural component for supplementation of existing natural populations?

7. Which life stage released (i.e. parr, presmolt, smolt) provides the quickest and highest response in rebuilding natural populations?

8. What effect does life stage released have on existing natural productivity and genetic composition?

These questions relate directly to questions 2, 3, 6, and 7 specified as important critical uncertainties by the Supplementation Technical Work Group (STWG 1988). In addition to addressing these questions with general application to the basin, our research will provide important case history evaluations of several supplementation programs in Idaho.

STUDY AREA

ISS represents a state-wide research effort incorporating treatment and control streams throughout the Clearwater River and Salmon River drainages. The study includes 8 treatment and 8 control streams in the Salmon River drainage (Figure 1) and 12 treatment and 3 control streams in the Clearwater River drainage (Figure 2). The 31 streams and the responsible agency are listed in Table 1. The IDFG supplementation crew concentrated on three streams in the Salmon River drainage and four in the Clearwater River drainage. The IDFG regional crews and other IDFG research crews sampled five other streams in the Salmon River drainage and five in the Clearwater River drainage. Table 2 lists these streams, the number of strata, the number of snorkel sites per strata, and the predominate channel type in each strata.

Most study streams are relatively sterile, draining granitic parent material associated with the Idaho batholith (IDFG et al. 1990; NPT and IDFG 1990). Two streams in the eastern part of the Salmon River drainage (Lemhi and Pahsimeroi rivers) are more fertile because they are spring fed and originate from basaltic parent material. The study streams are predominantly low to moderate gradient "headwater" streams with B- and C-channel characteristics (Rosgen 1985). Water quality is generally high with minimal contaminants and acceptable water temperatures. Habitat quality is fair to excellent with some localized riparian degradation, sedimentation, channelization, and irrigation withdrawal from multiple-use land management practices (IDFG et al. 1990; NPT and IDFG 1990).

Fish communities are relatively similar throughout the study streams. Anadromous fish include wild, natural, and hatchery-produced spring or summer chinook salmon and summer steelhead 0. mykiss. Resident fish comprise a mix of native bull trout *Salvelinus confluentus,* cutthroat trout 0. *clarki,* northern squawfish *Ptychocheilus oregonensis,* redside shiner *Richardsonius balteatus,* sculpin *Cottus spp.,* date *Rhinichthys spp.,* suckers *Catostomus spp.,* rainbow trout, mountain whitefish *Prosopium williamsoni* and introduced brook trout S. *fon tinalis.*

METHODS

Final evaluation of supplementation is dependent on the response of adult escapements to treatments. Several interim production and productivity evaluation points have been established to provide baseline information and initial feedback on population responses to treatments prior to adult returns. This report focuses on parr abundance, PIT tagging parr, fall and spring outmigration estimation and PIT tagging for outmigration survival estimates, as well as redd counts. A more detailed discussion of these evaluation points is contained in the ISS experimental design (Bowles and Leitzinger 1991).

Parr Abundance

Streams were stratified according to Rosgen's (1985) channel classification system (i.e. "C" channel indicates a meandering low gradient reach; "B" channel indicates a higher gradient confined channel). Each strata is predominantly B- or C-channel. Initial stratifications were done using U.S. Geological Survey (USGS) 7.5 min topographic maps. Aerial photographs and field validations were used to check stratifications prior to sampling.

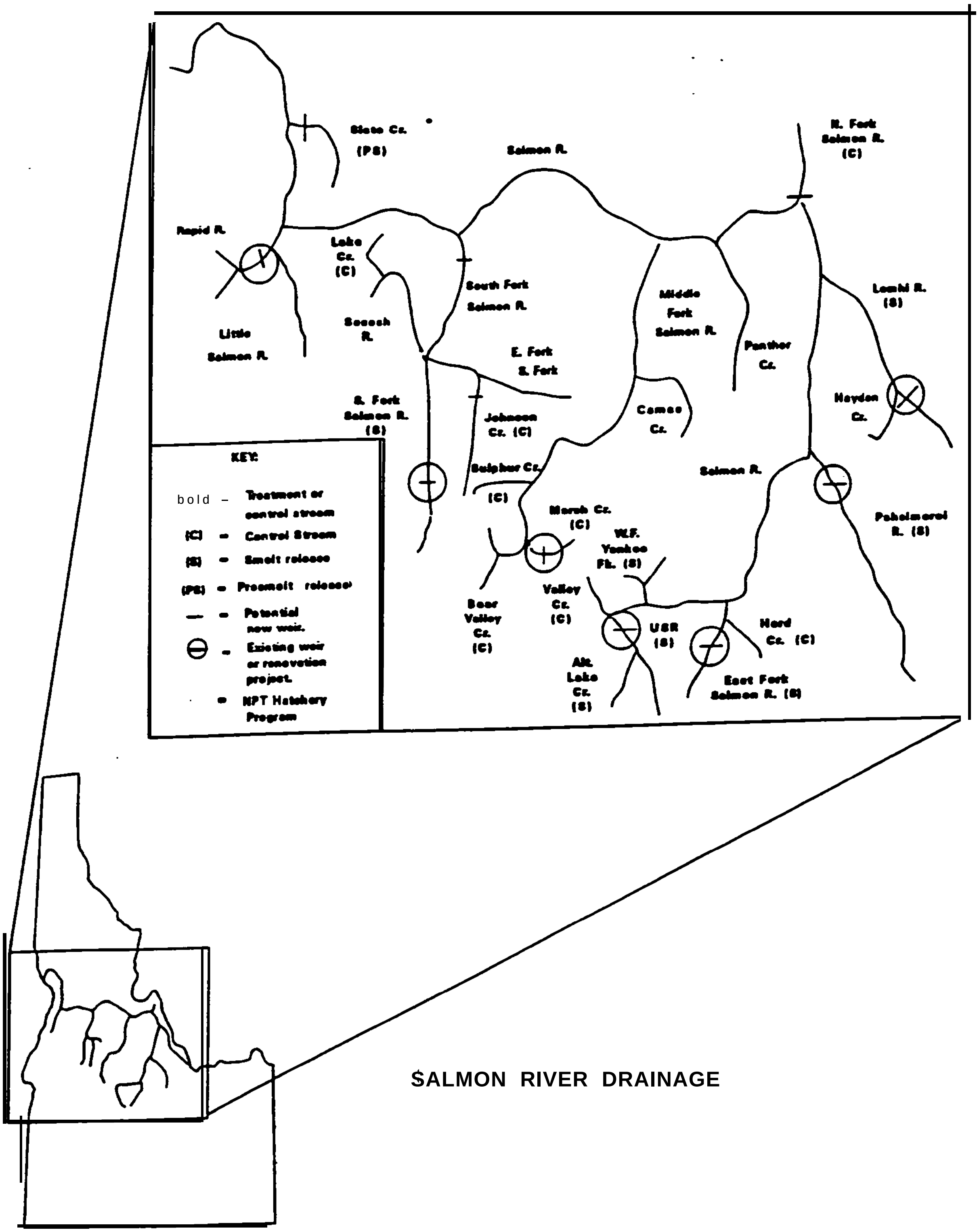


Figure 1. **Treatment and control streams in the Salmon River drainage associated with Idaho Supplementation Studies.**

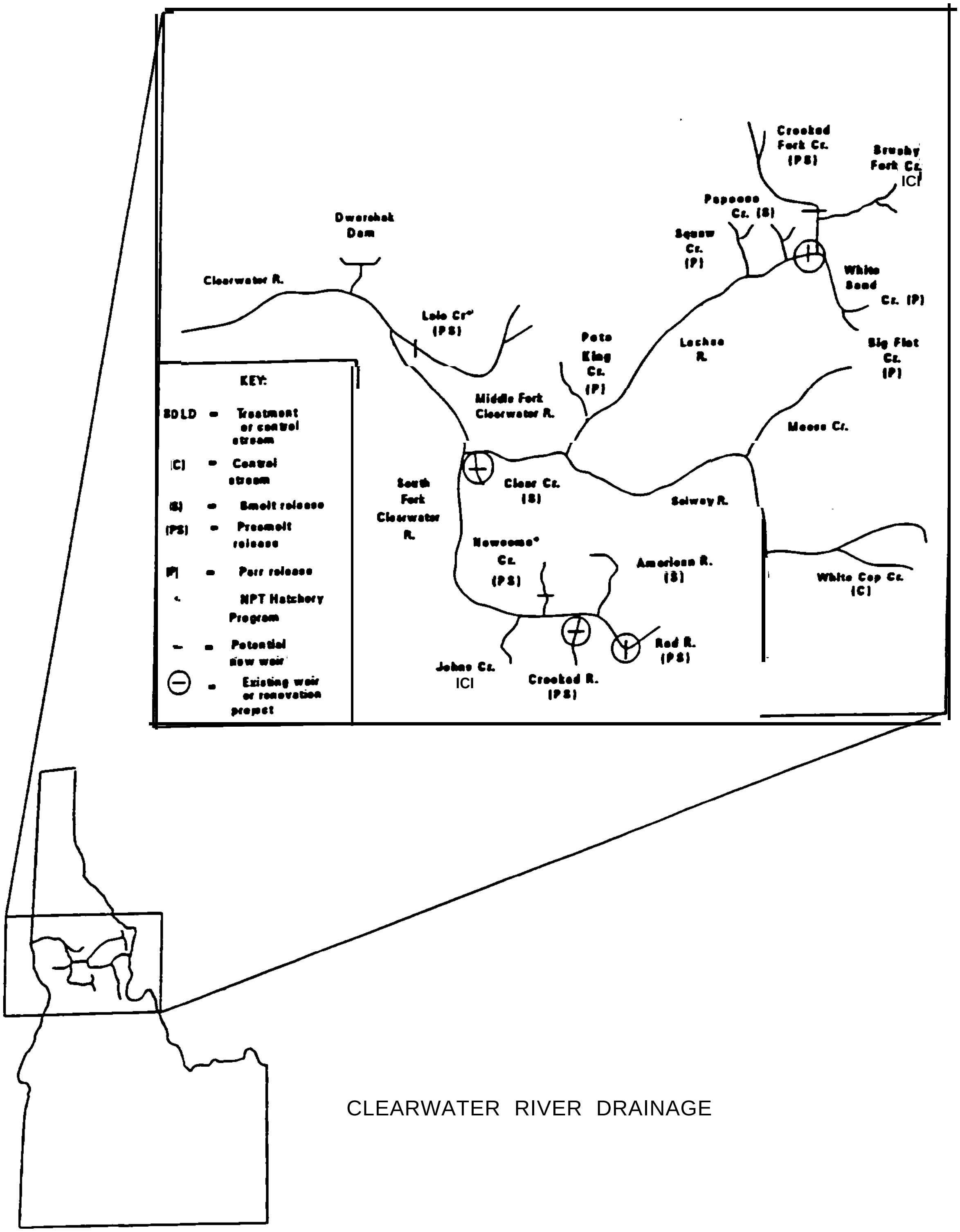


Figure 2. **Treatment and control streams in the Clearwater River drainage associated with Idaho Supplementation Studies.**

Table 1. ISS study streams and responsible agencies, summer 1993.

Agency	Stream	Treatment/ Control (T/C)
IDFG Idaho supplementation studies research crew	Marsh Creek	C
	Sulphur Creek”	C
	Pahsimeroi River	T
	Crooked Fork Creek	T
	Brushy Fork Creek	C
	White Sand Creek	T
	Big Flat Creek	T
IDFG Salmon Region	North Fork Salmon River	C
	Lemhi River	T
IDFG McCall Region	Johnson Creek	C
IDFG Clearwater Region	American River	T
	Red River	T
	Johns Creek	C
	White Cap Creek	C
IDFG Intensive smolt monitoring crew (BPA Project 9 I-073)	Crooked River	T
	Alturas Lake Creek	T
	Upper Salmon River	T
United States Fish and Wildlife Service	Pete King Creek	T
	Clear Creek	T
Nez Perce Tribe	Lolo Creek	T
	Squaw Creek	T
	Papoose Creek	T
	Newsome Creek	T
	Slate Creek	T
	Secesh River/Lake Creek	C
Shoshone-Bannock Tribes	Valley Creek	C
	West Fork Yankee Fork River	T
	East Fork Salmon River	T
	Herd Creek	C
	South Fork Salmon River	T
	Bear Valley Creek	C

Responsibility shared between IDFG Southwest Region and IDFG supplementation research.

Table 2. Salmon River and Clearwater River drainage streams snorkeled by IDFG supplementation research crews in 1993.

Stream	TrtlCnt	Strata	Number of sections	Channel type
Salmon River Drainage				
Pahsimeroi River	T	1	29	C
Total			29	
Sulphur Creek"	C	1	24	12b, 12c
		2	9	C
North Fork Sulfur Creek		1	4	2b, 2c
Total			37	
Marsh Creek	C	1	10	C
		2	21	C
Knapp Creek		1	10	C
Total			41	
Clearwater River Drainage				
Crooked Fork Creek	T	1	3	C
		2	5	B
		3	9	B
		4	13	B
		1	3	B
Total			33	
Brushy Fork Creek	C	1	0	
		2	19	B
		3	9	B
Spruce Creek		1	2	B
Total			30	
White Sand Creek	T	1	18	C
Total			18	
Big Flat Creek	T	1	8	C
Total			8	

Snorkeled together with IDFG Southwest Region staff.

Study sites within strata to be sampled were selected by a stratified-systematic procedure (Steel and Torrie 1980). Within each stratum, snorkeling sites (study sites) were located approximately every 400-800 m. Distances between sites varied according to accessibility, stream habitat types (i.e. pools, riffles, runs, and pocket water), and number of juvenile chinook salmon in surrounding sites. Sites were comprised of a pool/riffle sequence, or 50 m of uniform habitat, and they ranged from 30-50 m in length. Eight to 41 sites were snorkeled per drainage depending on stream size, accessibility, expected variance, and time constraints. Chinook salmon parr populations were estimated for each stratum, each habitat type within each stratum, and the entire stream (Schaeffer et al. 1979).

Each snorkel site was sampled to estimate chinook salmon parr abundance using Idaho's standardized snorkeling techniques (see Appendix A) Fish counts were recorded separately for each habitat type. Length and width measurements were recorded for each habitat sampled to determine densities (number/l00 m^2) per habitat. The date, time, water temperature, and visibility were also recorded. All snorkel sites were photographed (Polaroid and 35 mm) and flagged for future identification. All other salmonids seen were identified and recorded by species and inch class. The presence of nongame fish was also recorded.

Physical Habitat

Physical habitat surveys were recorded on two to three snorkel sites per stratum. Vertical drop, percent gradient (vertical drop/total transect length X 100), depth, substrate composition, and conductivity were measured. Vertical drop was measured, with a hand-held surveyors transit and a stadia rod, as the elevation drop between the upper and lower transect boundaries. Depth and substrate composition was determined at l/4, l/2, and 3/4 points across each width measurement. Surface substrate composition was estimated using a view box (30 cm X 30 cm). The percent of sand/silt (< 3 mm diameter), gravel (4-64 mm diameter), rubble (65-256 mm diameter), boulder (257-2.048 mm diameter), and bedrock (> 2,049 mm) were recorded according to Platts et al. (1983).

An additional habitat survey was conducted during redd counts. This entailed recording the habitat type (i.e. pool, riffle, run, and pocket water) every 10 to 40 paces over the length of the each stream included in the study. The number of paces varied depending on the length of the stream. This data was used to estimate the percent of each habitat type found in each strata. It was also used to calculate population estimates by habitat type.

Summer Parr PIT Tagjng

Juvenile chinook salmon (i.e. summer Parr) were PIT tagged following completion of snorkeling. Snorkelers aided in locating the fish. Collection of juveniles was possible only from streams with relatively high summer parr densities. Our goal was to tag a minimum of 700 parr per study stream. This number should ensure at least 60 detections at the lower Snake River dams (Kiefer and Forster 1990; Buettner and Nelson 1990). Fish were collected by electrofishing, seining, and using minnow traps. A Smith-Root (Model 15-B with Honda EX-350 Generator) backpack electrofishing unit was used in waters with sufficient conductivity. In streams with low conductivity, or those that were too deep or wide for electrofishing, collection methods were seining (1.8 m X 15.2 m with 6 mm green mesh) and minnow traps.

Fish were collected for PIT tagging when stream water temperatures were less than 20°C. Juveniles less than 60 mm (fork length) were not tagged. Juvenile chinook salmon PIT tagging procedures were defined by Kiefer and Forster (1991) and the PIT Tag Steering Committee (1992). PIT tagging data was recorded by using a PIT Tagging Station (Biomark Inc., Boise, Idaho) following methods outlined in Prentice et al. (1990). No more than 20 juveniles were anesthetized (MS2221 at one time, and equipment was sterilized in a 70% ethanol solution to reduce transmission of disease. Juveniles were held for 24 hours to observe lost tags and delayed mortality. Released fish were dispersed throughout the area they were captured.

Spring and Fall Emigrants

Rotary screw traps (EG Solutions, Corvallis, Oregon) were used to trap spring and fall emigrating juvenile chinook salmon. Our goal was to PIT tag a minimum of 500 fish throughout the spring migration period and 700 through the fall migration period. Tagged juveniles were released approximately 0.5-l .6 km upstream to estimate trap efficiency. Recaptures were released immediately downstream of the trap. Length and weight data were taken from parr PIT tagged in the summer and recaptured during the fall or spring trapping. These recaptures were also released downstream of the trap. All other salmonids captured were identified, measured, and released at the trap.

Screw traps were installed in Red River and Crooked Fork Creek in the Clearwater River drainage, and Marsh Creek, South Fork Salmon River, and Pahsimeroi River in the Salmon River drainage. The spring trapping season started in mid-March for the Clearwater River traps, and early April for the Salmon River traps. All traps were pulled in mid-June. The fall trapping lasted from mid-August to mid-November, except the Pahsimeroi trap. It was pulled in mid-December. The screw traps were located below hatchery weirs on the South Fork Salmon River and Pahsimeroi River, 400 m upstream of the mouth on Red River, and 3.2 km upstream of the mouth on Crooked Fork Creek. Traps were checked daily. Juveniles were anesthetized and tagged on the day captured. On the Pahsimeroi River, escaped hatchery juveniles (adipose-clipped) were tagged, recorded as hatchery fish, and released with the wild fish.

Spawning Escapement

Weirs

Existing weirs were operated by IDFG hatchery personnel with the exceptions of the Lemhi River weir (operated by ICFWRU personnel) and Marsh Creek (operated by ISS personnel). Adult chinook salmon were trapped, counted, sexed, and inoculated with erythromycin at the hatchery weirs.

Redd Counts

Redd counts were conducted in all streams to document spawning escapement and spatial spawning distribution. Redds were censused by ground crews throughout all possible spawning areas as outlined in IDFG Redd Count Manual (Hassemer 1991). All carcasses encountered were measured (fork length), sexed, and aged (estimate of years in ocean). Where possible, unspent eggs were counted to ascertain percent spawned and scales were taken. Estimates of age and sex were recorded for live adults on redds. Redd counts were conducted after peak spawning periods (Hassemer 1991). Remote streams were censused once and accessible streams were censused two or three times at one week intervals. Redds were flagged to avoid duplicate counts. All redds were marked on aerial photographs or USGS 7.5 min series topographical maps.

Broodstock Collection

Broodstock collection for supplementation began in 1991. All adult collections during 1991, 1992, and 1993 were by hatchery personnel at existing weirs used for general hatchery production programs. Hatchery personnel incorporated adult allocation and spawning protocols identified in the ISS experimental design (Bowles and Leitzinger 1991).

Rearing Marking, and Releases

Supplementation fish were reared in existing hatcheries and satellite facilities following standard hatchery practices. All treatment fish (i.e. hatchery reared) had representative numbers PIT tagged to evaluate relative survival from time of release to detection at the lower Snake River dams. Juveniles were PIT tagged in the hatchery prior to release. A minimum of 500 spring smolts and 1,000 summer parr and fall presmolts were PIT tagged for each release group. All treatment fish were marked initially with a right or left pelvic fin clip to enable evaluation of adult returns and ensure differentiation from natural adults for broodstock collection. Supplementation fish were released on-site, trucked to multiple release sites, or helicoptered to multiple release sites in each study stream.

RESULTS

Summer Parr Abundance and PIT Tagging

Juvenile chinook salmon abundance was estimated for 17 streams snorkeled by ISS and other IDFG crews. The ISS crew was responsible for estimating chinook salmon populations on seven of those streams (Table 1, Appendices B and C). Two techniques were used to estimate the total population. One technique used in 1991, 1992, and 1993 combines all the habitat types snorkeled and chinook salmon observed in each site to estimate the total number of chinook salmon per site. Lengths of each habitat type were added to get total length of each site. Widths of each habitat were combined to get an overall average width of the entire site. In other words, habitat type is not considered. A site may be made up of any one habitat type or any combination of the four (pools, riffles, runs, pocket water). The estimates for each stratum are then added to get total population for the stream (Figure 3, Table 3, Appendix B). We refer to this technique as "population estimation by strata." The second technique requires stratifying each site into habitat types and recording the lengths, average widths, and numbers of chinook salmon observed separately for each habitat type. The result is a population estimate for each habitat type in each stratum (e.g. number of chinook salmon in pools in strata II for Brushy Fork Creek). These estimates are then added together to estimate the total

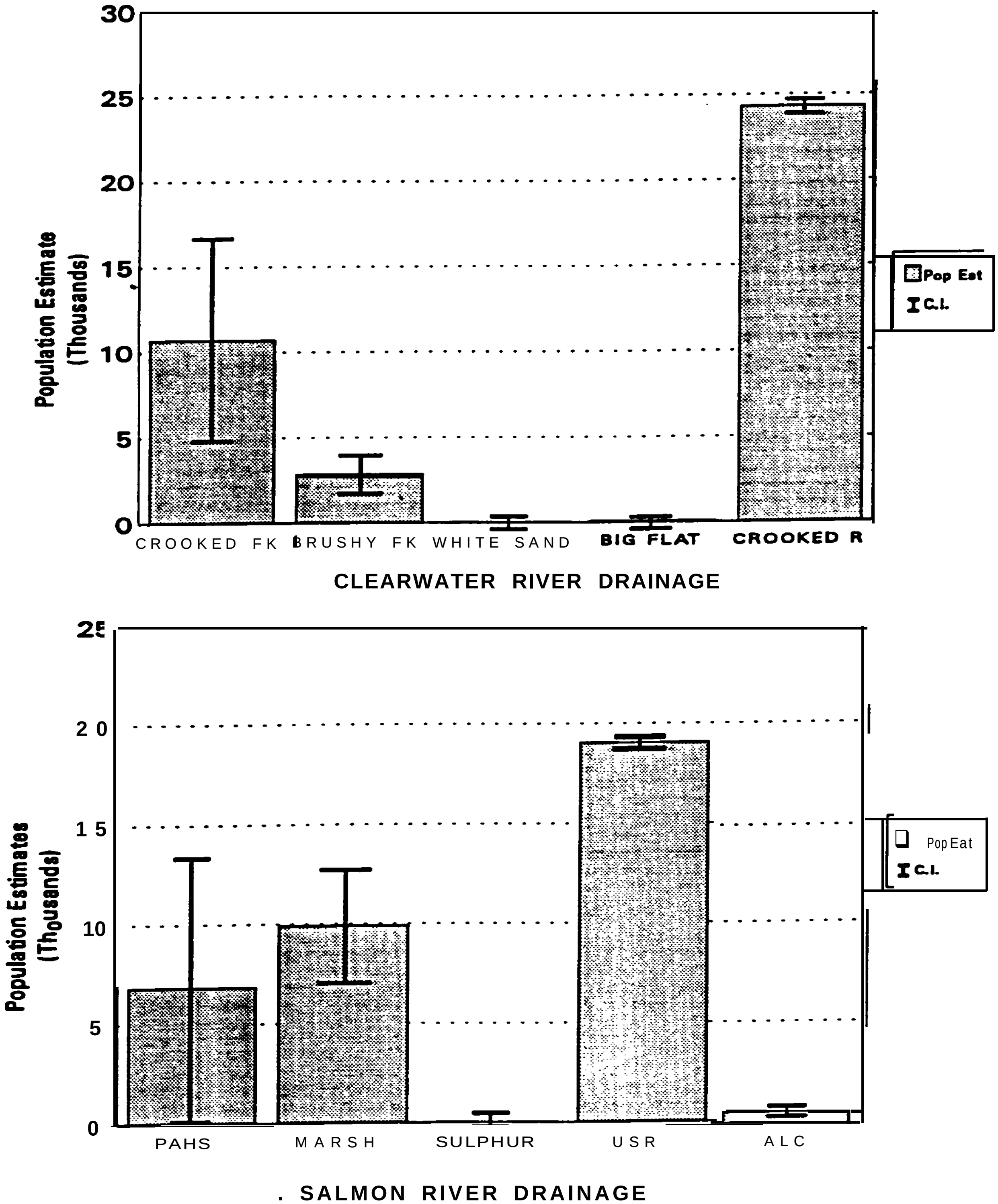


Figure 3. 1993 chinook salmon parr population estimates by strata for ISS study streams.

Table 3. Chinook salmon parr population estimates (based on strata or habitat types within strata) and 90% confidence intervals, summer 1991-1993.

	By Strata						By Habitat Type	
	1991		1992		1993		1993	
Stream	Chinook population estimate	90% C.I. (% of pop. estimate)	Chinook population estimate	90% C.I. (% of pop. estimate)	Chinook population estimate	90% C.I. (% of pop. estimate)	Chinook population estimate	90% C.I. (% of pop. estimate)
Pahsimeroi River	21,396	11,837 (55.32)	41,600	35,516 (85.38)	6,840	6,564 (95.97)	5,930	6,804 (114.74)
Marsh Creek[a]			17,151	3,223 (18.79)	9,899	2,758 (27.86)	6,822	1,458 (21.37)
Sulphur Creek			4,478	2,329 (52.01)	28	32 (114.29)	41	59 (143.90)
Crooked Fork Creek[b]	13,304	7,009 (52.68)	3,622	1,727 (47.68)	10,725	5,880 (54.83)	8,949	4,429 (49.49)
Brushy Fork Creek[c]	-		9,933	4,280 (43.09)	2,828	1,093 (38.65)	1,770	461 (26.05)
White Sand Creek	1,910	1,220 (63.87)	2,795	2,652 (94.88)	46	54 (117.39)	14	15 (107.14)
Big Flat Creek	0	0 (0.00)	0	0 (0.00)	95	177 (186.32)	29	53 (182.76)

[a] Includes Knapp Creek.
[b] Includes Hopeful Creek.
[c] Includes Spruce Creek.

population per stratum, and then the strata estimates are added to get total stream population (Figure 4, Table 3, Appendix C). We refer to this method as "population estimation by habitat."

Chinook salmon population estimates by stratum ranged from 46 in White Sand Creek to 10,725 in Crooked Fork Creek, while densities ranged from 0.03 fish/l00 m^2 in White Sand Creek to 10.6 fish/l00 m^2 in Marsh Creek'(Figure 3, Table 3, Appendix B). Chinook salmon estimates by habitat ranged from 14 in White Sand Creek to 6,822 in Marsh Creek (Figure 4, Table 3, Appendix C). Generally chinook salmon parr estimates were lower than the previous two years (Table 3).

The ISS crew PIT tagged only 515 chinook salmon parr in three streams during 1993 (Table 4). Numbers of fish PIT tagged ranged from a high of 223 in Crooked Fork Creek to a low of 130 in the Pahsimeroi River. Brushy Fork Creek was intermediate with 162 chinook salmon parr tagged. No lost tags or mortalities were observed after 24 hours. Table 5 lists the National Marine Fisheries Service's (NMFS) summer parr PIT tagging results. Data from 10 of the 17 streams will be incorporated into ISS.

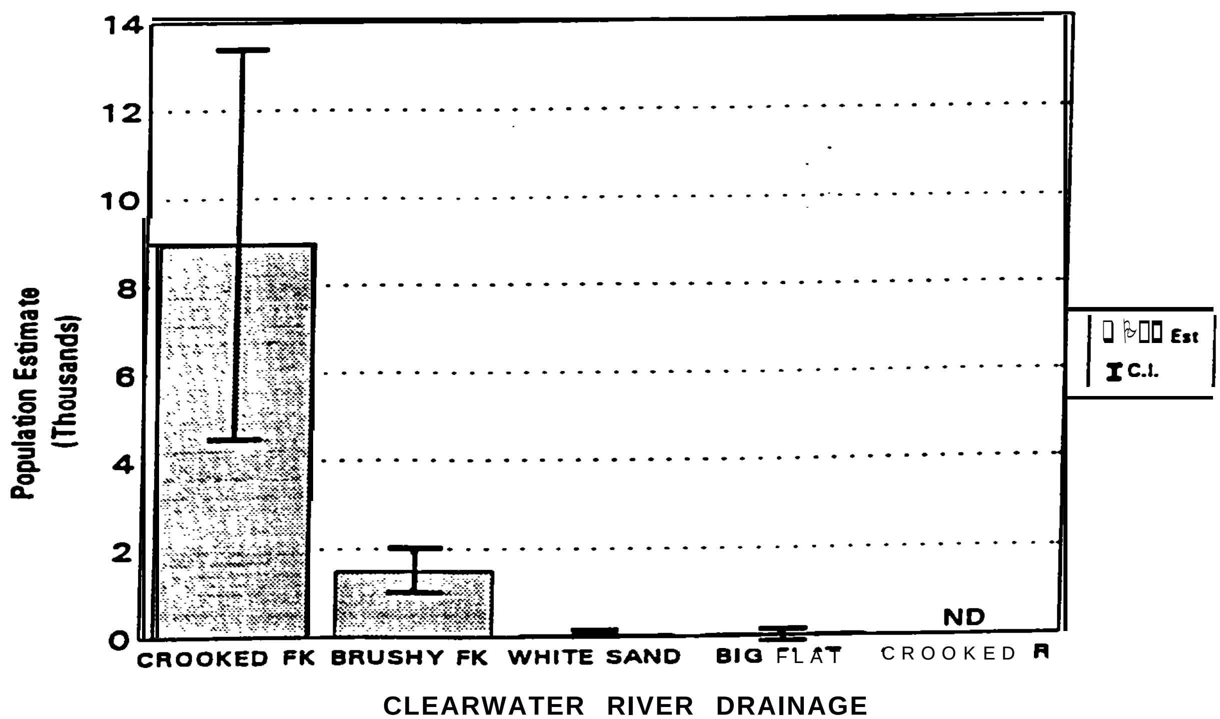
Physical Habitat

The physical habitat data for each snorkel site is being summarized and put into a database. The habitat type survey has been summarized (Table 6) and has been used to calculate population estimates by habitat.

Spring Outmiaration Trapping and PIT Tagging

Spring outmigration trapping began on March 17 and ended June 14. Table 7 summarizes the chinook salmon trapping and tagging. The majority of chinook salmon smolts migrated past the traps prior to the high water. The peaks in smolt migration appear associated with the new moon (Figures 5-9) as in 1992 (Leitzinger et al. 1993). Trap efficiencies for chinook salmon smolts ranged from zero in the Pahsimeroi (no natural smolts tagged in the spring were recaptured, so an efficiency estimate was not possible) to 28% in Marsh Creek (Table 7).

The number of young-of-the-year (YOY) chinook salmon fry trapped ranged from 36 in Red River to 2,474 in the South Fork Salmon River. These fry were too small to tag and in most cases still had their yolk sac. The exception was the Pahsimeroi River where 44 fry were tagged. These fish were substantially larger than the YOY at the other traps. The outmigration cues are not as clear for the YOY. Fry movement in Marsh Creek mostly ceased before the peak in the hydrograph. The major peak fry movement in the South Fork was also prior to the peak runoff, but there was also a peak coinciding with the peak runoff, and a third peak as water levels were dropping. In fact, the numbers of fry trapped were quite high (about lOO/day) until the trap was pulled. Fry in the Pahsimeroi started appearing in the trap late in the trapping season. This coincided with dropping water levels indicating the beginning of the irrigation season. The spring runoff in the Pahsimeroi is typically removed for irrigation, so while other streams are experiencing peak runoff flows, the Pahsimeroi River's flow is decreasing. We do not know if this is affecting YOY chinook salmon movement. Fry in both Crooked Fork Creek and Red River also started showing up late in the trapping season as water



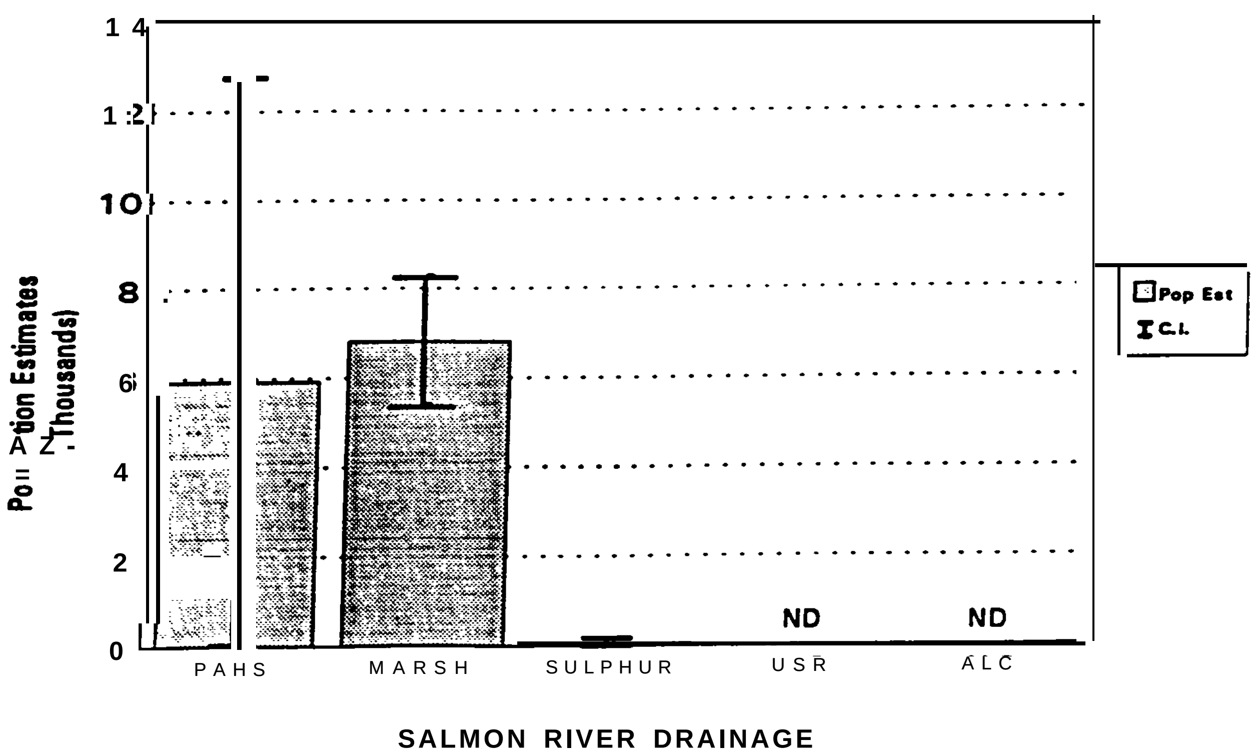


Figure 4. 1993 chinook salmon parr population estimates by habitat for ISS study streams.

Table 4. IDFG ISS parr PIT tagging summary, summer 1993.

Tributary	Number tagged	Number of mortalities (%I	Number of lost tags (%)	Number of fish released	Number collected for genetics
Pahsimeroi River	130	0	0	130	21
Brushy Fork Creek	162	0	0	162	35
Crooked Fork Creek	223	0	0	223	20

Table 5. Numbers of chinook salmon parr PIT tagged by NMFS crews, summer 1993 IS. Achord, NMFS. personal communication).

Tributary	Number tagged	Number of Tagged Mortalities	Number Released
Bear Valley Creek•	860	4	856
Elk Creek•	999	1	998
East Fork Salmon River•	885	2	883
Herd Creek	119	0	119
South Fork Salmon River•	809	4	805
Secesh River•	422	0	422
Lake Creek•	252	0	252
Marsh Creek•	963	3	960
Rush Creek	10	0	10
Sulphur Creek•	0	0	0
Valley Creek•	835	0	835
Camas Creek	215	0	215
Loon Creek	396	0	396
Upper Big Creek	535	0	535
Lower Big Creek	187	1	186
Chamberlain Creek	76	0	76
West Fork Chamberlain Creek	504	4	500

• will be used in ISS

Table 7. Numbers of emigrating juvenile chinook salmon trapped and PIT tagged (young-of-the-year and smolts) at five sites during spring 1993.

Tibutary	Total Trapped	Total Tagged	Released at Trap	Released Above Trap (Tagged)	Trap Efficiency Recapture	Trap Efficiency (%)	Summer Recaps.	Down Stream Recaps.	Trap Mort. # (%)	Tag Mort. # (%)	Other Mort. # (%)
Crooked Fork Creek											
Smolts (wild)	329	308	47	273	15	5.49	0	0	6(1.82)	2(0.65)	1(0.30)
YOY (wild	56	0	54	0	0	0.00	0	0	2(3.57)	0(0)	0(0)
Smolts (hatchery1	14	12	2	12	2	16.67	0	0	0(0)	0(0)	0(0)
Red River											
Smolts (wild)	695	588	116	565	102	18.05	3	0	7(1.01)	8(1.36)	0(0)
YOY (wild	36	0	35	0	0	0.00	0	0	l(2.78)	0(0)	0(0)
Smolts (hatchery)	90	2	88	2	0	0.00	1	0	0(0)	0(0)	0(0)
Marsh Creek											
Smolts (wild)	226	174	51	174	49	28.16	0	0	1(0.44)	0(0)	0(0)
YOY (wild	773	0	765	0	N/A	N/A	NIA	N/A	8(1.03)	N/A	0(0)
South Fork Salmon River											
Smolts (wild)	190	171	20	168	17	10.12	0	0	2(1.05)	0(0)	0(0)
YOY (wild	2,474	0	2,474	0	NIA	N/A	N/A	0	0(0)	NIA	0(0)
Smolts (hatchery)	10,697	51	10,288	51	0	0.00	N!A	0	358(3.35)	0(0)	0(0)
Pahsimeroi River											
Smolts (wild)	63	62	1	62	0	0.00	0	0	0(0)	0(0)	0(0)
YOY (wild	46	44	8	38	2	5.26	0	0	0(0)	OIOI	0(0)
Smolts (hatchery)	2,399	1	2,306	92	1	1.09	0	0	1(0.04)	0(0)	0(0)

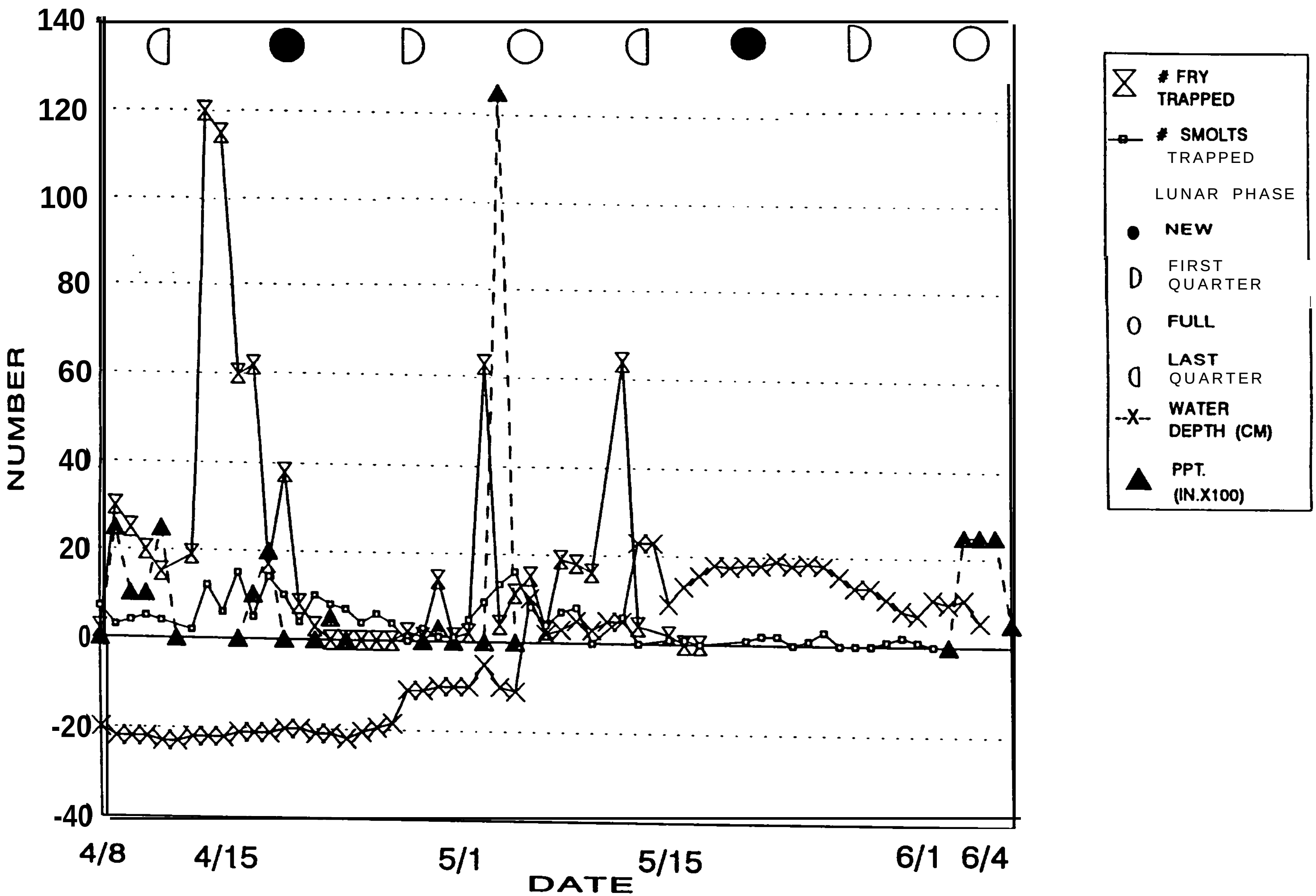


Figure 5. Daily trap results, lunar phase, precipitation, and water depth for Marsh Creek, spring 1993.

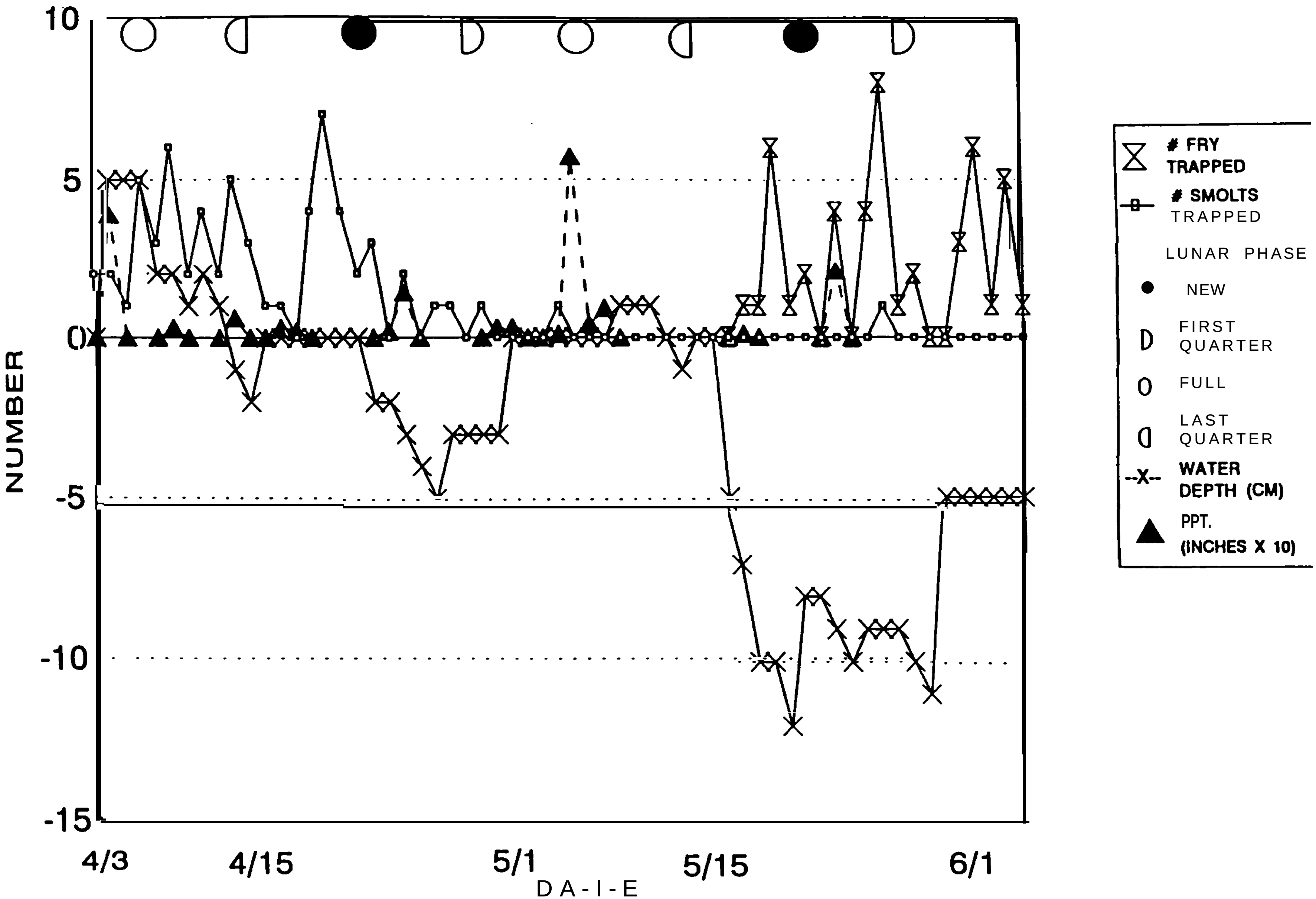


Figure 6. Daily trap results, lunar phase, precipitation, and water depth for the Pahsimeroi River, spring 1993.

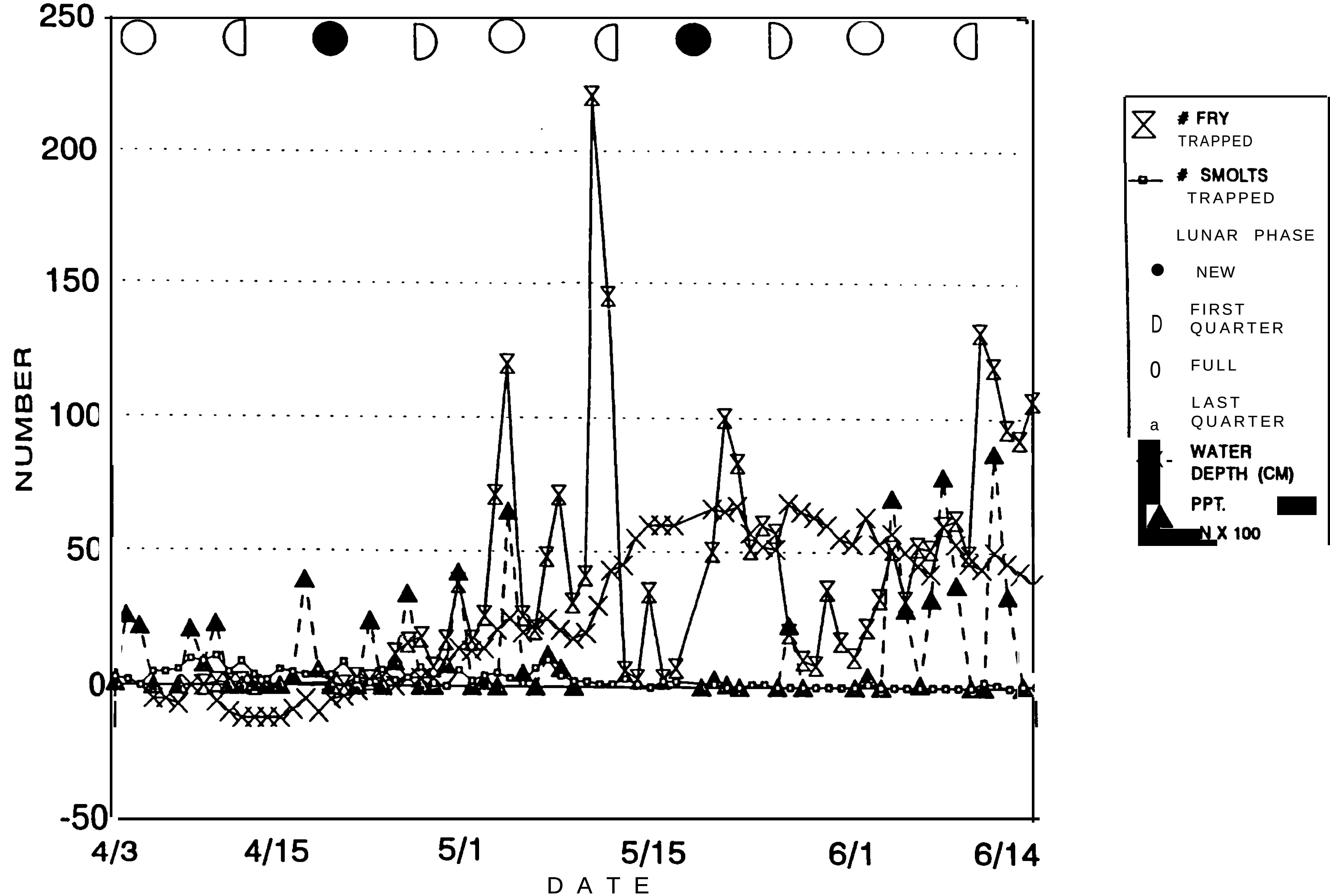


Figure 7. **Daily trap results, lunar phase, precipitation, and water depth for the South Fork of the Salmon River, spring 1993.**

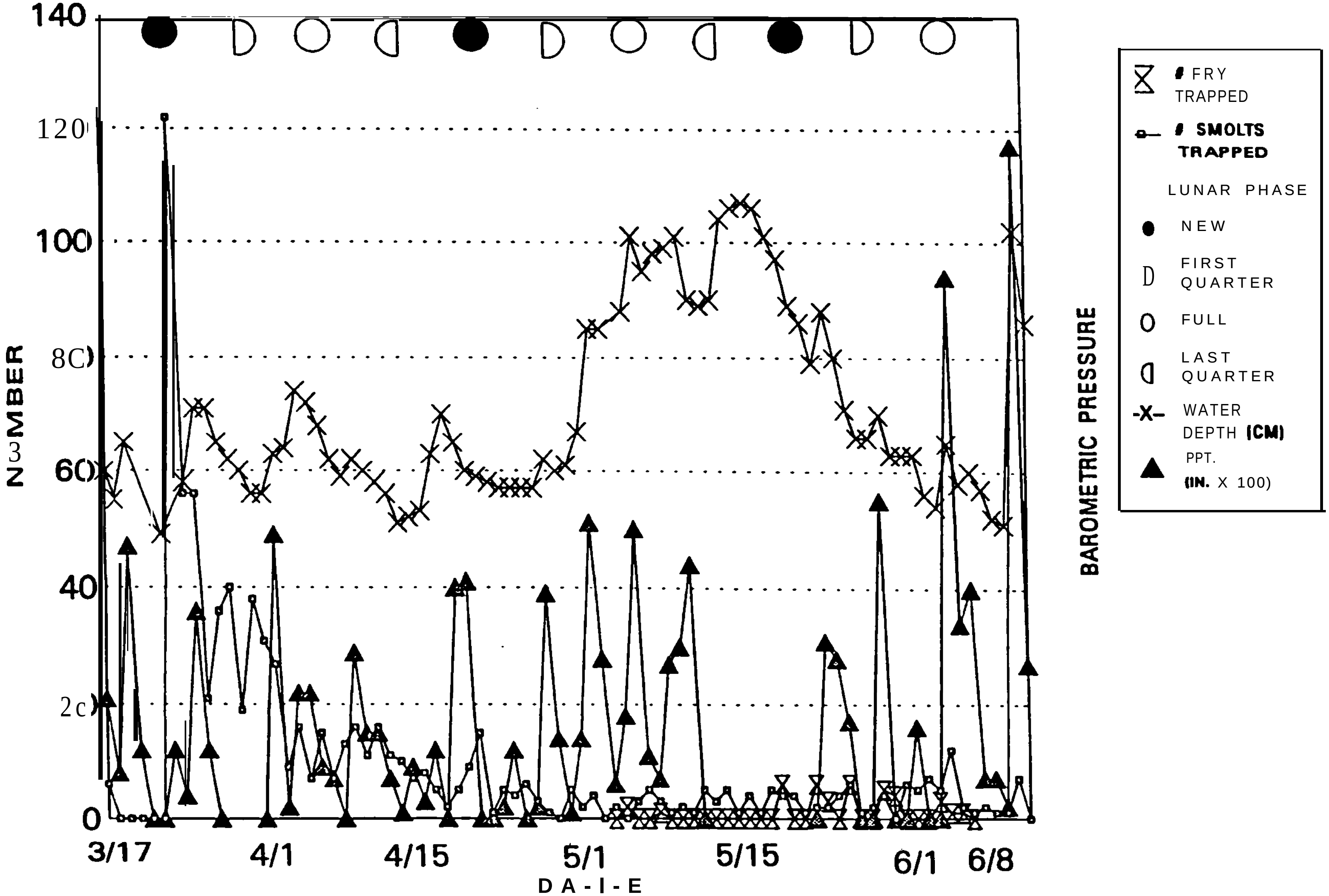


Figure 8. Daily trap results, lunar phase, precipitation, and water depth for Red River, spring 1993.

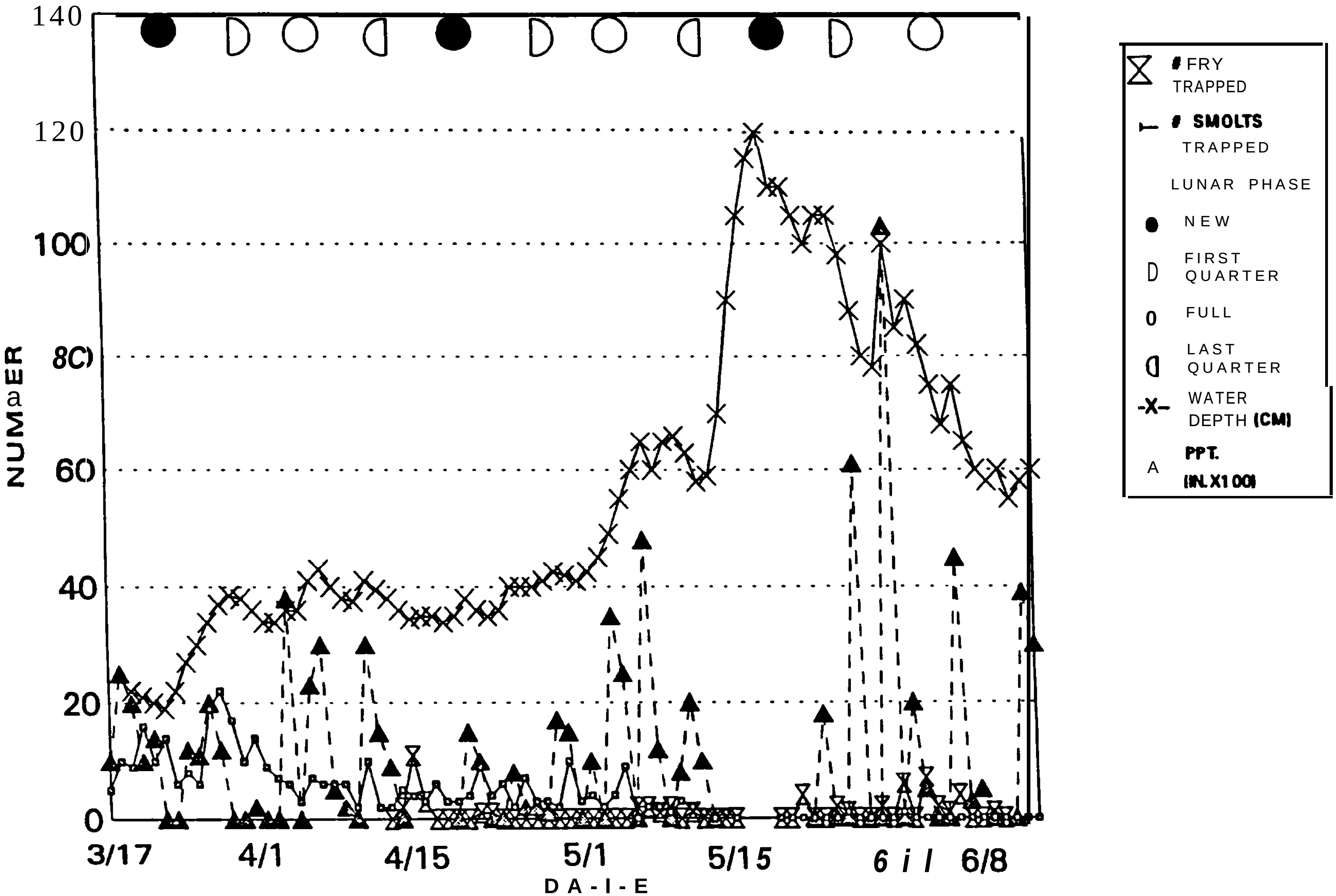


Figure 9. Daily trap results, lunar phase, precipitation, and water depth for Crooked Fork Creek, spring 1993.

levels began rising. But, the numbers remained low during the peak of the runoff and increased as flows decreased. This variation in fry movement is probably due to several factors such as distance between the trap and the redds, differences in spawn timing between streams, redd density, water temperatures, and elevation differences.

The number of chinook salmon smolts tagged ranged from 62 in the Pahsimeroi River to 588 in Red River. Wild/natural chinook salmon smolt outmigration estimates ranged from a low of 629 in Marsh Creek to a high of 5,715 smolts in Crooked Fork Creek (Table 8). We also estimate that 72 hatchery chinook salmon migrated past the Crooked Fork Creek trap during the spring trapping.

Trapping and tagging mortality was quite low (Table 7). Trapping mortality was lowest (i.e. zero) in the Pahsimeroi for naturally-produced chinook salmon smolts and YOY, as well as for hatchery-produced smolts in Crooked Fork Creek and Red River, and natural YOY in the South Fork Salmon River. It should be noted that the hatchery fish overwintered in Crooked Fork Creek and Red River after being released the previous fall. The highest trapping mortality was 3.57% on Crooked Fork Creek YOY. However, the actual number dying was quite low, only 2 of the 56 YOY trapped died. The greatest number of trapping related deaths was 358 (3.35%) hatchery smolts released into the South Fork Salmon River. This is an estimate, not a complete count of the trapping mortalities. The hatchery fish were released above our trap and we were not informed of the release until after the fact. As a result, the trap got overloaded with fish and approximately one-third of the fish in the trap died (≈350 out of an estimated 1,000 fish).

Several other hatchery smolts died in the trap at later dates. Most of these later mortalities had injuries that appeared to have been caused prior to entering the trap (e.g. bulging or bloody eyes, large abrasions, fin damage, etc.). In all other cases, trapping mortality was below 2%. Tagging mortality was extremely low. Mortality due to tagging occurred at only two of the five traps. Red River was the highest with 1.36% mortality (eight fish), while Crooked Fork Creek tag mortality was 0.65% (two fish).

Table 9 summarizes steelhead and resident fish trapped. Other fish trapped in the rotary screw traps include bull trout, cutthroat trout, brook trout, mountain whitefish, juvenile steelhead, sculpin, redside shiners, suckers, dace, and Pacific lamprey Lampetra *tridentata* (Red River only).

PIT Tag Detections

PIT tag detections for hatchery and wild/natural brood year 1991 (outmigration year 1993) chinook salmon associated with ISS are summarized in Table 10. Detection facilities were operating at four dams on the lower Snake and Columbia Rivers (Lower Granite, Little Goose, Lower Monumental, and McNary dams). Fish were tagged at three juvenile life stages, summer Parr, fall emigrants, and spring emigrants. The summer parr had the lowest detection rates. They ranged from 1.79Oh for hatchery fish released into White Sand Creek to 15% for Johnson Creek wild fish.

Fall emigrant detection rates ranged from 1.5% for Sawtooth Hatchery fish released above the hatchery to 24.89% for Crooked Fork Creek natural chinook salmon.

Spring migrants had the highest detection rates as expected. They ranged from 18% for Sawtooth Hatchery fish released above the hatchery to 51.61% for Pahsimeroi River natural chinook salmon. Generally, at all life stages wild/natural chinook salmon had higher detection rates than the hatchery fish.

Table 8. Estimates of smolt outmigration during trapping period, spring 1993.

Stream	Outmigrants trapped”	Trap efficiency recapture”	Trap efficiency	Estimated outmigrants[c]
Crooked Fork Creek				
Wild	314	151273	5.49%	5,715
Hatchery	12	2/12	16.67%	72
Red River				
Wild	593	1021565	18.05%	3,285
Hatchery	90	0/2	N/A	N/A
Marsh Creek				
Wild	177	49/1 74	28.16%	629
South Fork Salmon River				
Wild	173	17/1 68	10.12%	1,710
Hatchery	10,697	0/51	N/A	N/A
Pahsimeroi River				
Wild Smolts	63	0162	N/A	N/A
Wild YOY	44	2/38	5.26%	836
Hatchery	2,398	1/92	1.09%	220,616[d]

[a] Minus trap efficiency recaptures and downstream recaptures.

[b] The denominator represents the number of tagged fish released above the trap, the numerator represents the number of those fish that were recaptured.

[c] Calculated by dividing the number of outmigrants trapped by the trap efficiency.

[d] 375,000 hatchery fish were released on 4/21/93. Trap was out of operation during the peak outmigration of hatchery fish, therefore the estimate is low.

Table 9. Incidental catch trapping summary, spring 1993.

Length class (Mm)	Steelhead tagged	Steelhead not tagged	Incidental catches (not PIT tagged)				
			Brook trout	Bull trout	Cutthroat trout	Whitefish	Pacific lamprey
Marsh Creek 04/08/93 - 06/06/93							
≤ 63	0	100	0	0	0	0	
64-139	62	395	11	4	0	48	
140-215	35	2	1	4	0	0	
216-317	2	0	0	0	0	0	
≥ 318	0	0	0	0	0	0	
TOTAL	99	497	12	8	0	48	
Pahsimeroi River 04/03/93 - 06/02/93							
≤ 63	0	1	2	0	0	0	
64-139	0	49	1	0	0	0	
140-215	0	29	1	0	0	0	
216-317	0	6	0	0	0	0	
≥ 318	0	1	0	0	0	0	
TOTAL	0	86	4	0	0	0	
Salmon River, South Fork 04/03/93 - 06/14/93							
≤ 63	128	169	1	2	0	0	
64-139	297	287	2	4	0	3	
140-215	24	0	1	0	1	0	
216-317	1	0	0	0	0	0	
≥ 318	0	0	0	0	0	1	
TOTAL	450	456	4	6	1	4	
Red River 03/18/93 - 06/08/93							
≤ 63	0	0	0	0	0	0	1
64-139	0	69	0	1	2	23	95
140-215	0	172	0	0	1	4	508
216-317	0	1	0	0	1	3	45
≥ 318	0	0	0	0	0	0	0
TOTAL	0	242	0	1	4	30	649
Crooked Fork Creek 03/17/93 - 06/08/93							
≤63	2	37	0	0	0	0	
64-139	78	51	0	0	8	1	
140-215	416	90	0	0	4	0	
216-317	1	4	0	0	0	0	
≥318	0	1 (762mm♂)	0	0	0	0	
TOTAL	497	183	0	0	12	1	

Table 10. ISS chinook salmon detections at Lower Granite, Little Goose, Lower Monumental, and McNary dams for the 1993 outmigration.

River	Season Tagged								
	Summer 1992			Fall 1992			Spring 1993		
	Number Tagged	Number Detected	Percent	Number Tagged	Number Detected	Percent	Number Tagged	Number Detected	Percent
Brushy Fork	217	16	7.37						
Crooked Fork			-	W[a] 912 H 48	w 227 H 7	W 24.89 H 14.58	W 305 H 12	w 152 H 5	W 49.84 H 41.67
Johnson Creek	640	96	15.00						
Sulphur Creek	712	51	7.16						
Marsh Creek	1,000	115	11.50				174	73	41.95
North Fork Salmon	513	43	8.38						
Pahsimeroi	483	34	7.04	w 587 H 73	W 82 H 3	W 13.97 H 4.11	W 62 H 600	W 32 H 196	W 51.61 H 32.70
Red River Pond			-	H 951	H 33	H 3.47			
Red River	294	31	10.54	271	38	14.02	W 579 H 2	w 259 H 0	w 44.73 H 0.00
South Fork Salmon	1,004	123	12.25	695	163	23.45	W 171 H 175	w 58 H 55	W 33.92 H 31.43
Squaw Creek	H 700	H 23	H 3.29						
White Sand Creek	H 1,399	H 25	H 1.79						
Sawtooth above Busterback			-	H[b] 1,600	H 91	H 5.70			
Sawtooth below Busterback			-	H[c] 800	H 12	H 1.50			
Sawtooth						-	H[d] 801	H 144	H 18.00
McCall"						-	H 2,013	H 732	H 36.36

[a] W = wild, H = hatchery.
[b] Combination of low and medium density rearing groups.
[c] High density rearing group.
[d] Fish were released at three locations: two above Busterback and one below the diversion.
[e] Released into South Fork Salmon River at Knox Bridge.

Fall Outmigration Trapping and Pit Tagging

Fall outmigration trapping began August 19 and ended December 15 (Table 11). Between 596 and 6,627 chinook salmon emigrants were captured and tagged at five screw trap sites (Table 11). The numbers of emigrants trapped and tagged do not include precocious males. Trap efficiencies ranged from 3.18 to 55.96%. Trapping mortality ranged from 0.0 to 3.08% (2 of 65 fish) and 24-hour delayed tagging mortality ranged from 0.0 to 0.56%.

Our estimates of total fall emigrants ranged from 4,338 wild/natural chinook salmon in the Pahsimeroi River to 32,312 in the South Fork Salmon River (Table 12). Emigration occurred predominately at night and was highest following storm events and during dark lunar phases (Figures 5 through 14). Unlike the fall of 1992 (see 1992 annual report - Leitzinger et al. 1993) and the spring of 1993, the outmigration cues are not quite so apparent. There are peaks in outmigration during or immediately prior to a new moon in the South Fork Salmon River (Figure 10), Red River (Figure 11) and Crooked Fork Creek (Figure 12). Although outmigration peaks occurred in association with new moons in both Marsh Creek (Figure 13) and the Pahsimeroi River (Figure 14), the largest peaks in outmigration occurred during a full moon. The peak outmigration in the Pahsimeroi River was mostly escaped hatchery fish; there was also a coinciding smaller peak of naturally-produced fish.

When comparing the summer parr population estimates (Table 3, Appendices B and C) to the total numbers of fish trapped and estimated number of emigrating chinook salmon during the trapping season (Tables 11 and 12). it is clear that the majority of fish in these streams outmigrate in the fall. In some cases, the number of chinook salmon trapped or the estimated number of migrants was almost as high as or exceeded our summer parr population estimates. This is further indication of problems with our snorkel estimates.

Table 13 summarizes steelhead and resident fish trapped. Other fish trapped during the fall outmigration were the same as in the spring. The peak of Pacific lamprey movement appears to be in the spring.

Spawning Escapement

Weirs

Adult salmon were collected for broodstock at all IDFG hatchery weirs on ISS study streams. A percentage of the run was passed above each of the hatchery weirs to spawn naturally. At least 60% of each run was passed above the Sawtooth, East Fork Salmon River, Pahsimeroi River, and South Fork Salmon River weirs. Approximately one-third of the adult salmon were passed at the Crooked River weir, while two-thirds were passed at the Red River weir. All fish were passed above the Lemhi River and Marsh Creek weirs to spawn naturally (Table 14). These fish were not innoculated. Their sex and age were determined while they were being passed. The temporary weir was not in place in Crooked Fork Creek, so no broodstock was collected for Crooked Fork Creek supplementation.

The numbers of adult chinook salmon trapped ranged from 90 at the East Fork Salmon River trap to 2,703 at the South Fork Salmon River trap. The hatchery and natural components

Table 11. Numbers of emigrating juvenile chinook salmon trapped and PIT tagged at five sites during fall, **1993.**

Tributary	Total Trapped	**Total** Tagged	Released at Trap	Released Above Trap (Tagged)	Trap Effective Recap.	Trap Efficiency (%)	Summer Recap.	Down Stream Recap.	Trap Mortality Number (%)	Tag Mortality Number (%)	Other Mortality Number (%)
Crooked Fork Creek (Wild)	2,320	1,868	490	1,823	346	18.98	1	4	6(0.26)	1(0.05)	0(0)
Precocious ♂	12	0	12	0	N/A	N/A	0	0	0(0)	N/A	0(0)
Red River (Wild)	1,161	1,005	186[b]	972	155	15.95	0	0	1(0.09)	1(0.10)	1(0.09)
Precocious ♂	14	6	a	6	1	16.67	0	0	0(0)	0(0)	0(0)
(Hatchery)	1,535	0	1,535	0	N/A	N/A	0	0	0(0)	0(0)	0(0)
Marsh Creek (Wild)	13,371	6,627	6,653	6,555'	3,668	55.96	142	51	31(0.23)	30(0.25)	0(0)
Precocious ♂	65	2	61	2	1	50.00	0	0	2(3.08)	0(0)	0(0)
South Fork Salmon River (Wild)	6,716	4,677	2,017[d]	4,620	838	18.14	9	17	48(0.71)	26(0.56)	5(0.07)
Precocious ♂	33	0	32	0	N/A	N/A	0	0	1(3.03)	N/A	0(0)
Pahsimeroi River											
Box (Wild)	46	46	0	46	0	0	0	0	0(0)	0(0)	0(0)
Precocious ♂	6	0	6	0	N/A	N/A	0	0	0(0)	N/A	0(0)
Screw trap (Wild)	434	387	72	357[d]	33	9.24	5	0	4(0.92)	0(0)	I(0.23)
Precocious ♂	7	3	4	3	0	0	0	0	0(0)	N/A	0(0)
Screw trap (Hatchery)	377	163	220	157	5	3.18	1	0	0(0)	0(0)	0(0)

[a] Includes 44 tagged fish not used in trap efficiency estimate.
[b] Includes 32 tagged fish not used in trap efficiency estimate.
[c] 102 additional chinook were released above trap without tags, not included in trap efficiency estimate.
[d] Includes 31 tagged fish not used in trap efficiency estimate.
[e] Only tagged parr released above screw trap were used in trap efficiency estimate.

Table 12. Estimates of presmolt outmigration during trapping period, fall 1993.

Stream	Outmigrants Trapped”	Trap Efficiency Recapture[b]	Trap Efficiency	Estimated Outmigrants[c]
Crooked Fork Creek				
Wild	1,970	34611,823	18.98%	10,380
Red River				
Wild	1,006	155/972	15.95%	6,309
Hatchery	1,535	0	N/A	N/A
Marsh Creek				
Wild	9,652 -	3,668/6,555	55.96%	17,249
South Fork Salmon River				
Wild	5,861	83814,620	18.14%	32,312
Pahsimeroi River				
Box (Wild)	46	0	N/A	N/A
Screw Trap (Wild)	401	33/357	9.24%	4,338
Hatchery	372	5/I 57	3.18%	11,681

[a] Minus trap efficiency, recaps, and downstream recaps.

[b] The denominator represents the number of tagged fish released above the trap, the numerator represents the number of those fish that were recaptured.

[c] Calculated by dividing the number of outmigrants trapped by the trap efficiency.

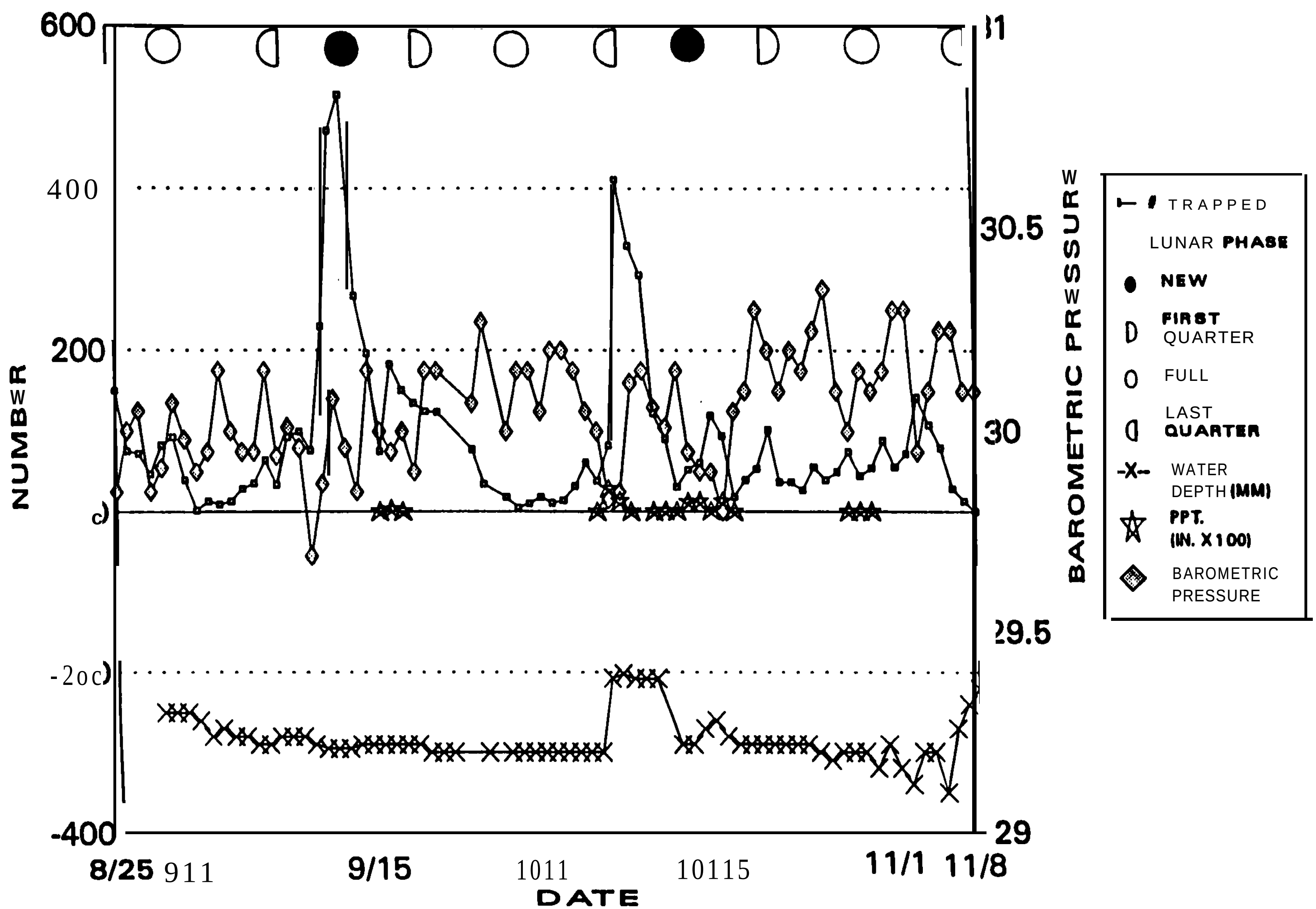


Figure 10. Daily chinook salmon trap results, lunar phase, water depth (cm), and precipitation (inches x 100) for Marsh Creek, fall 1993.

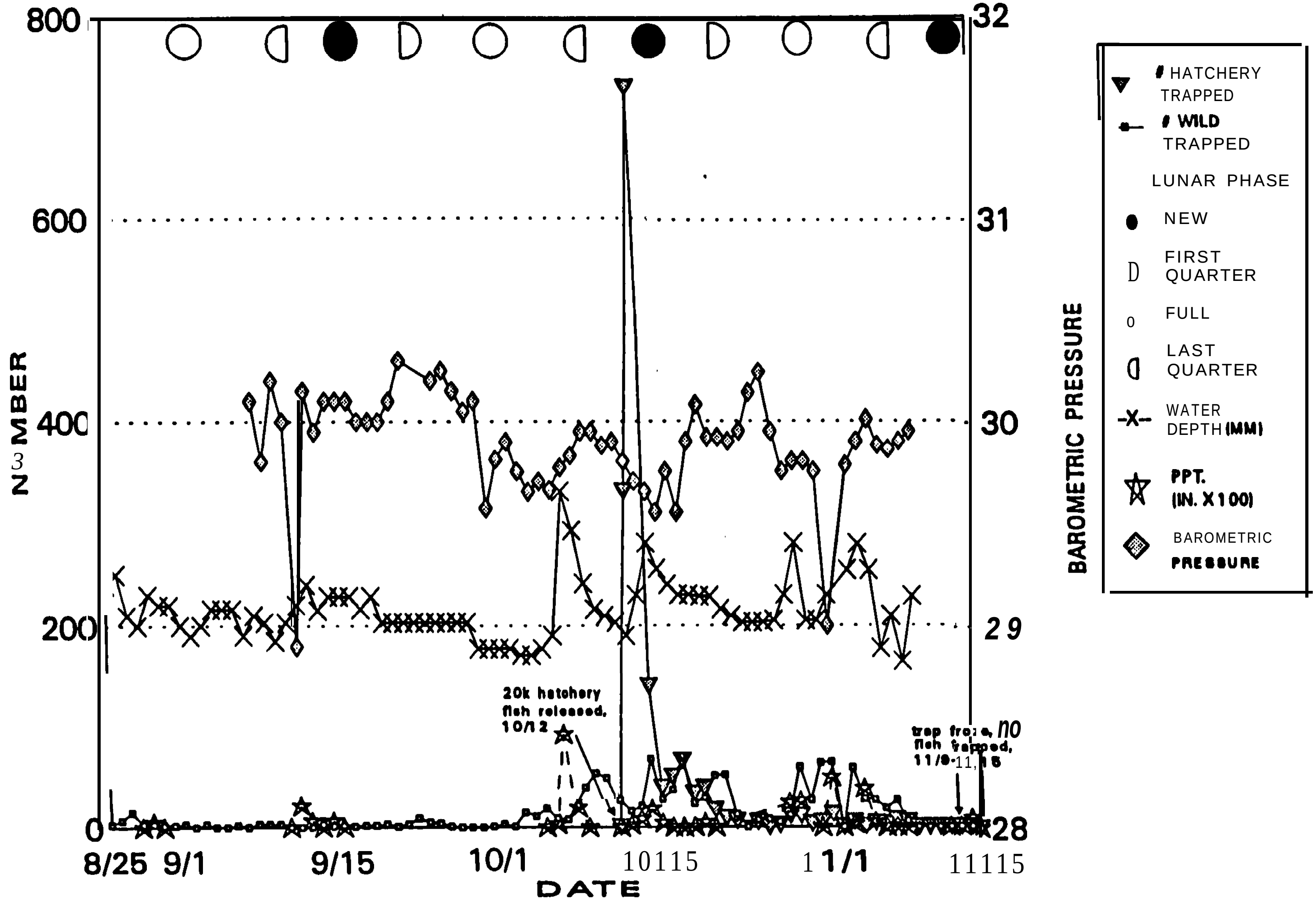


Figure 11. Daily chinook salmon trap results, lunar phase, water depth (cm), precipitation (inches x 100), and barometric pressure for the Pahsimeroi River, fall 1993.

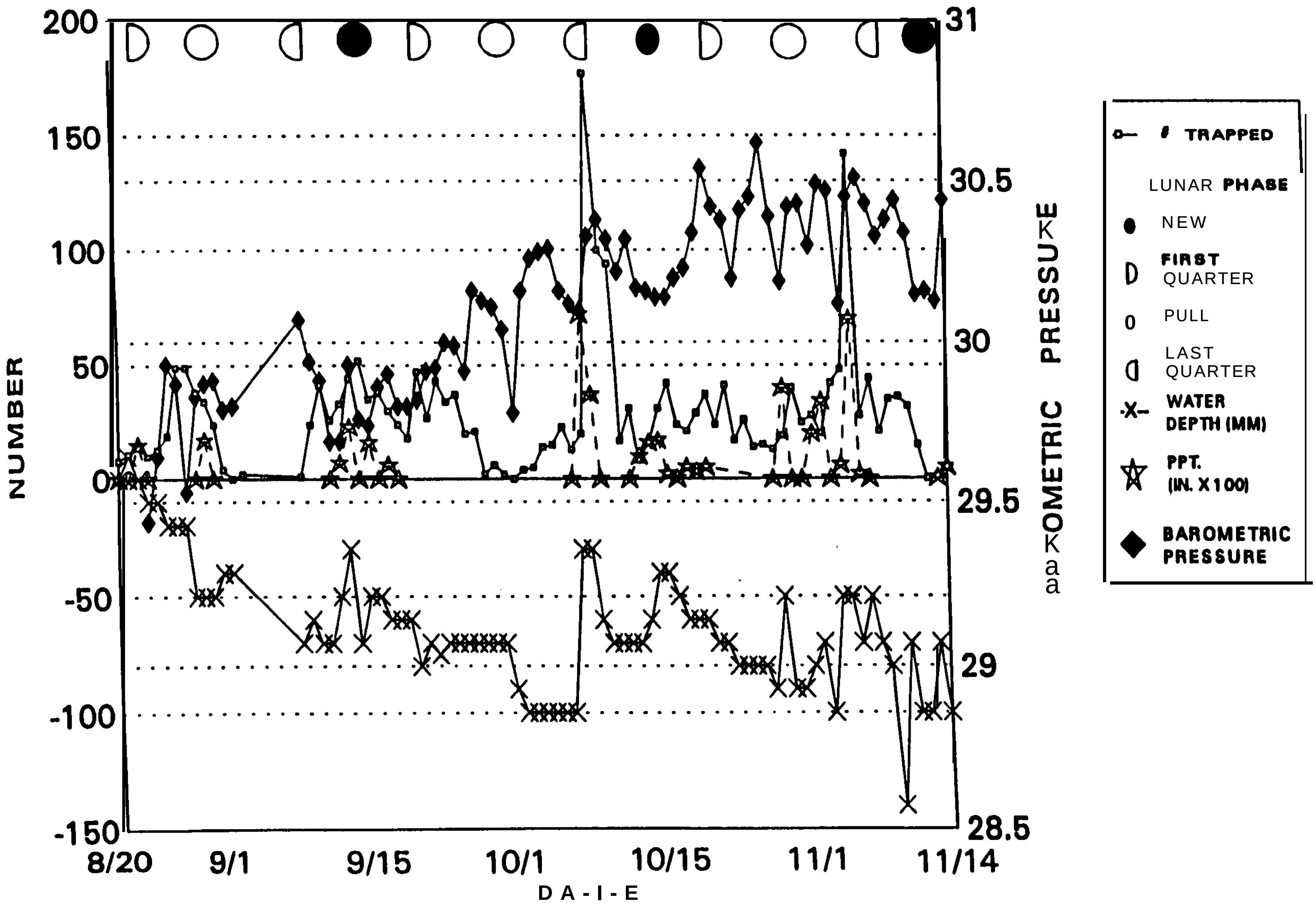


Figure 12. Daily chinook salmon trap results, lunar phase, water depth (mm) precipitation (inches x 100), and barometric pressure for the South Fork Salmon River, fail 1993.

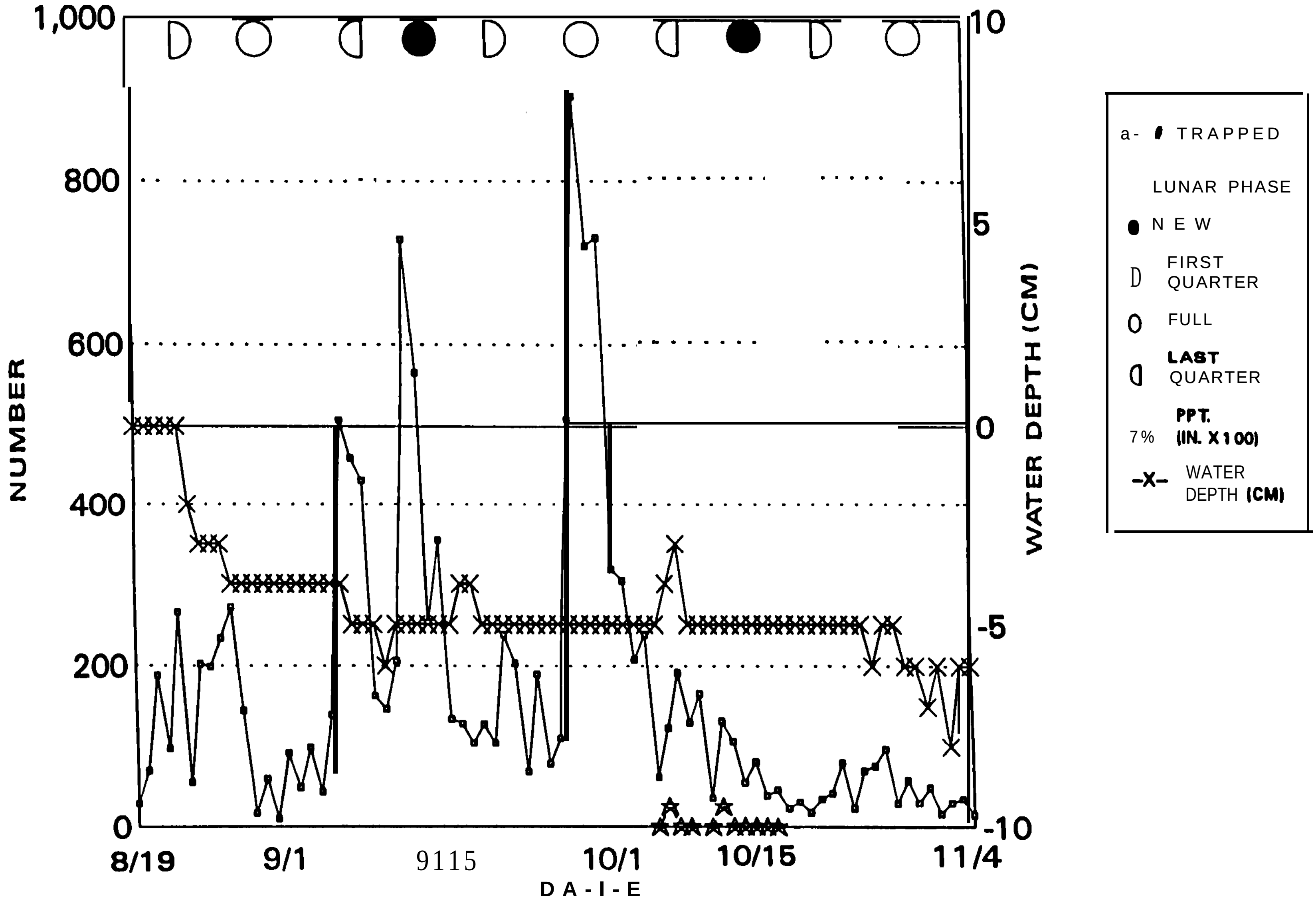


Figure **13. Daily chinook salmon trap results, lunar phase, water depth (mm), precipitation (inches x 100), and barometric pressure for Red River, fall 1993.**

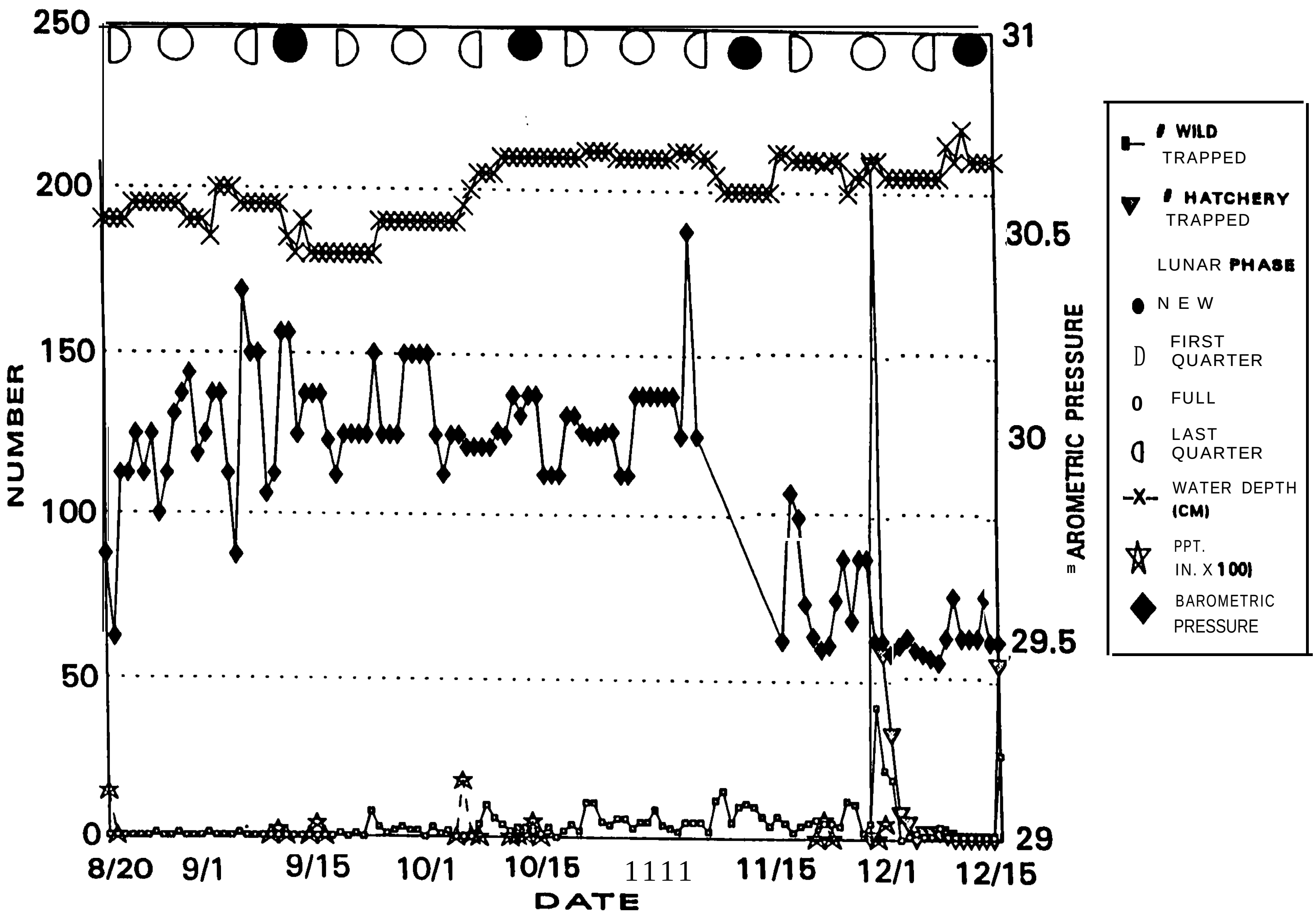


Figure 14. Daily chinook salmon trap results, lunar phase, water depth (mm), precipitation (inches x 100), and barometric pressure for Crooked Fork Creek, fall 1993.

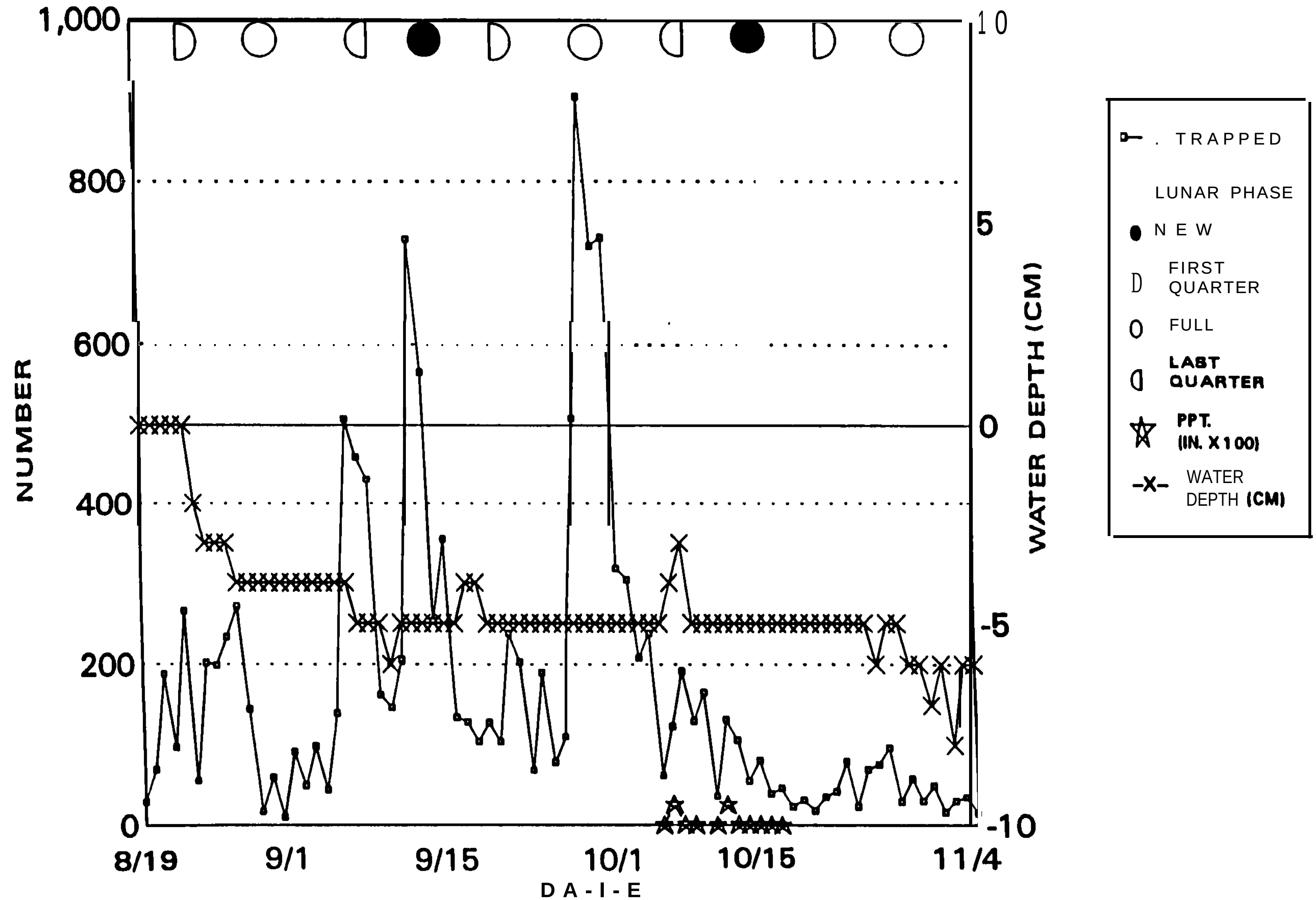


Figure 13. Daily chinook salmon trap results, lunar phase, water depth (mm), precipitation (inches x 100), and barometric pressure for Red River, fall 1993.

Table 13. Incidental catch trap summary, fall 1993.

Length class (mm)	Steelhead tagged	Steelhead not tagged	Incidental catches (not PIT-Tagged)				
			Brook trout	Bull trout	Cutthroat trout	Whitefish	Pacific lamprey
Marsh Creek 08/19/93 - 11/04/93							
≤ 63	6	65	8	0	0	11	
64-139	142	32	336	1	2	9	
140-215	50	5	220	22	1	22	
216-317	0	0	6	2	3	71	
≥ 318	0	0	0	0	4	10	
Total	198	102	570	25	10	208	
Pahsimeroi River (box trap) 09/16/93 - 10/03/93							
≤ 63	0	0	0	0	0	0	
64-139	0	17	17	0	0	28	
140-215	0	24	6	0	0	1	
216-317	0	4	4	0	0	1	
≥ 318	0	1	0	0	0	1	
Total	0	46	27	0	0	31	
Pahsimeroi River (screw trap) 08/20/93 - 12/15/93							
≤ 63	0	9	0	0	0	4	
64-139	0	93	18	1	0	95	
140-215	0	42	13	0	0	21	
216-317	0	11	1	0	0	0	
≥ 318	0	5	0	0	1	0	
Total	0	160	32	1	1	120	
Salmon River, South Fork 08/25/93 - 11/08/93							
≤ 63	22	101	1	1	3	8	
64-139	258	2	12	5	0	6	
140-215	257	1	10	36	1	2	
216-317	20	1	2	8	1	16	
≥ 318	0	0	0	2	0	7	
Total	557	105	25	52	5	39	
Red River 08/25/93 - 11/08/93							
≤ 63	6	11	1	0	0	12	12
64-139	57	12	71	0	0	18	0
140-215	98	20	45	5	6	14	0
216-317	9	9	4	4	20	10	0
≥ 318	2	3	0	4	8	6	0
Total	172	55	121	13	34	60	12
Crooked Fork Creek 08/20/93 - 11/14/93							
≤ 63	25	17	0	0	1	1	
64-139	37	1	0	0	0	0	
140-215	214	3	0	3	21	0	
216-317	1	0	0	4	1	20	
≥ 318	0	‘0	0	4	11	6	
Total	277	21	0	11	34	27	

Table 14. Adult chinook salmon returns to IDFG hatchery weirs used with ISS, 1993.

Weir Location	Total trapped	Males trapped	Males spawned	Males released	Male mortality	Females trapped	Females spawned	Females released	Female mortality
Red River	139	74	23	49	7 ’	65	23	42	0
Crooked River	402	191	129 [b]	77	30	211	129	75	7
Powell	500	258	207 [b]	25	50 [a]	242	207	15 ’	20
Sawtooth	587	307	93	214 [d]	0	280	68	209 [d]	3
East Fork Salmon River	90	57	13	44	0	33	11	21	1
South Fork Salmon River	2,703	1,216	356	704	156	1,487	356	940	143
Pahsimeroi River	169	79	23	74	0	90	29	61	0

[a] = Incomplete counts.
[b] = Assumed because of 1 :1 spawning.
[c] = Outplanted in White Sand Creek at the Colt Creek bridge.
[d] = Includes 86 males and 86 females released for ISS.

Table 15. Adult chinook salmon trapping data for Marsh Creek. Ages are based on the length-frequencies of adults trapped each year.

Year	Trapping period (run period)	Number of chinook salmon trapped												Trapping mortalities	
		Total				Males				Females					
		Age 3	Age 4	Age 5	Total	Age 3	Age 4	Age 5	Total	Age 3	Age 4	Age 5	Total	Males	Females
1993	6/30-10/9 (7/3-8/22)	0	14	94	108	0	11	54	65	0	3	40	43	0	0

of these runs are not known. The number of female salmon spawned ranged from 11 at the East Fork to 356 at the South Fork Salmon River. The number of salmon released upstream to spawn ranged from 15 at Powell (released into White Sand Creek at the Colt Creek trailhead) to 940 in the South Fork Salmon River (Table 14). In the South Fork Salmon River, 100 pairs were trucked up to Stolle Meadows to spawn. The remaining 740 adults were released just upstream of the weir. Also, 165 pairs of salmon were trucked from Rapid River Hatchery to American River and released.

Table 15 summarizes adult salmon returns to Marsh Creek. The Marsh Creek weir was installed on June 30. The first adult salmon was trapped on July 3, and the last was trapped on August 22. A total of 108 salmon were trapped and passed (65 males and 43 females). There was no prespawning mortality observed. The weir was pulled on October 9. The peak of the run was from July 21 to the end of the month (Figure 15). Most of the returning adults are five year old fish, based on length measurements (Figure 16).

The live box on the Marsh Creek weir was modified. It was relocated to the upstream side of the weir in the middle of the stream, and it has a trap door on the upstream side of the live box that can be lifted so adults can swim out of the box without being handled. Also, the new live box is larger than the previous live box.

Redd Counts

Chinook salmon redds were counted by ISS crews on 13 study streams (Figure 17, Appendix D). Table 16 summarizes redd counts in ISS study streams in 1992 and 1993. Redd counts in the Salmon River drainage ranged from a high of 694 in the South Fork Salmon River (area covered was from the weir to the headwaters including Curtis Creek) to a low of 44 in Johnson Creek. In the Clearwater River drainage, the redd counts ranged from a high of 209 in American River to a low of 0 in the Johns Creek drainage. The high count in American River is at least partly due to the 165 pairs trucked in from Rapid River Hatchery.

Broodstock Collection

A portion of the adult chinook salmon trapped at the upper Salmon River, South Fork Salmon River, East Fork Salmon River, Pahsimeroi River, Crooked River, and Red River weirs were retained as broodstock and spawned (Table 14). Progeny of these fish will be used to supplement existing natural populations. Returns to the Powell facility will be used to supplement upper Lochsa River tributaries without viable populations (White Sand, Big Flat, Pete King, Papoose, and Squaw creeks).

Rearing, Marking, and Release

Chinook salmon outplants into treatment streams are summarized in Table 17. In early August, a total of 144,000 parr from the Powell satellite facility were released in restoration treatment streams (i.e. treatment streams without an existing naturally reproducing chinook salmon population) in the upper Lochsa River drainage. Squaw and Pete King creeks each received 12,000 with 1,000 PIT tagged. The remaining 120,000 were helicoptered into the upper White Sand Creek drainage (80,000 into White Sand Creek above Big Flat Creek, and 40,000 into Big Flat Creek). All fish were left ventral fin-clipped.

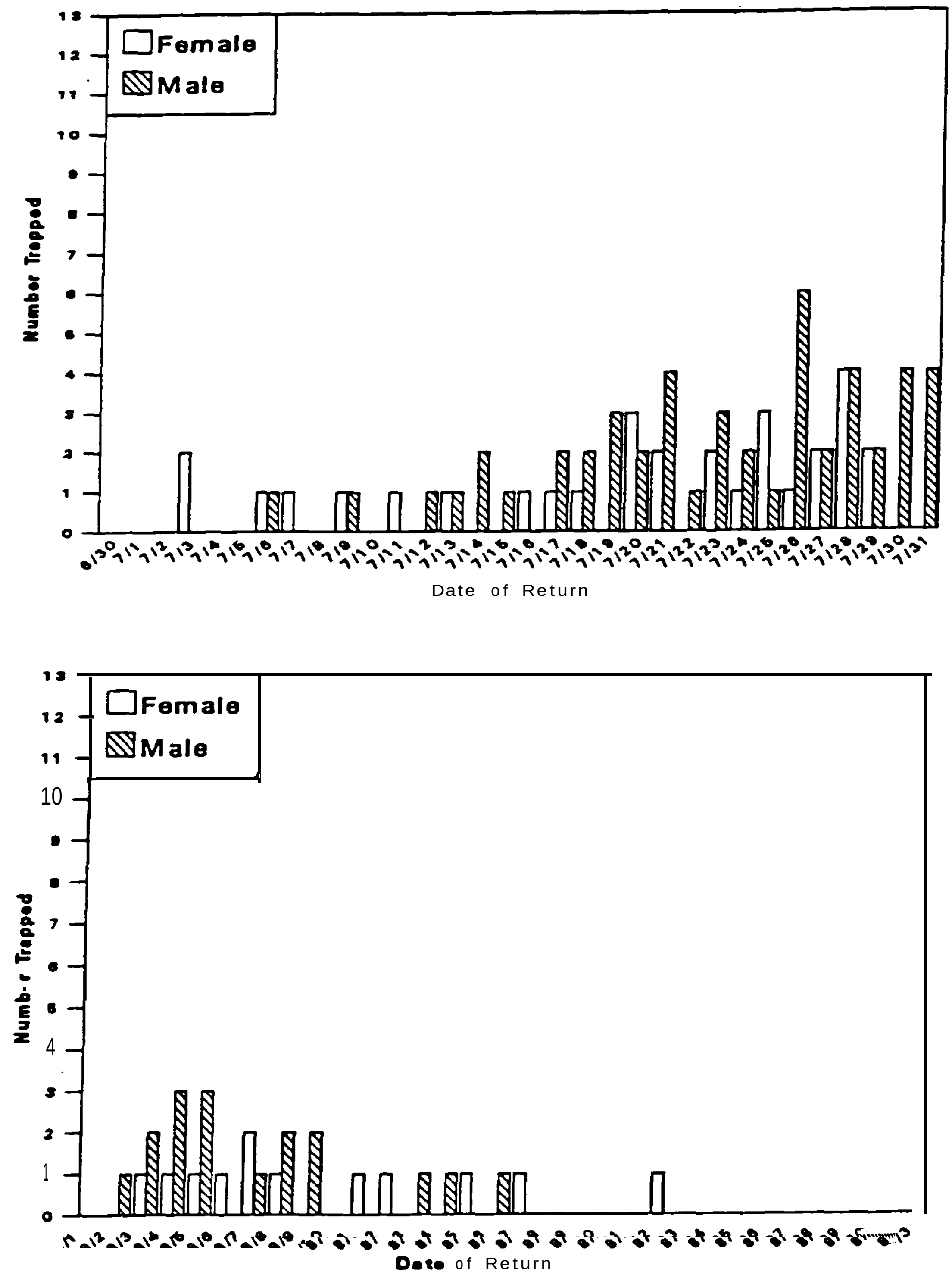


Figure 15. Dates trapped and sex of adult chinook salmon returning to Marsh Creek weir, summer 1993.

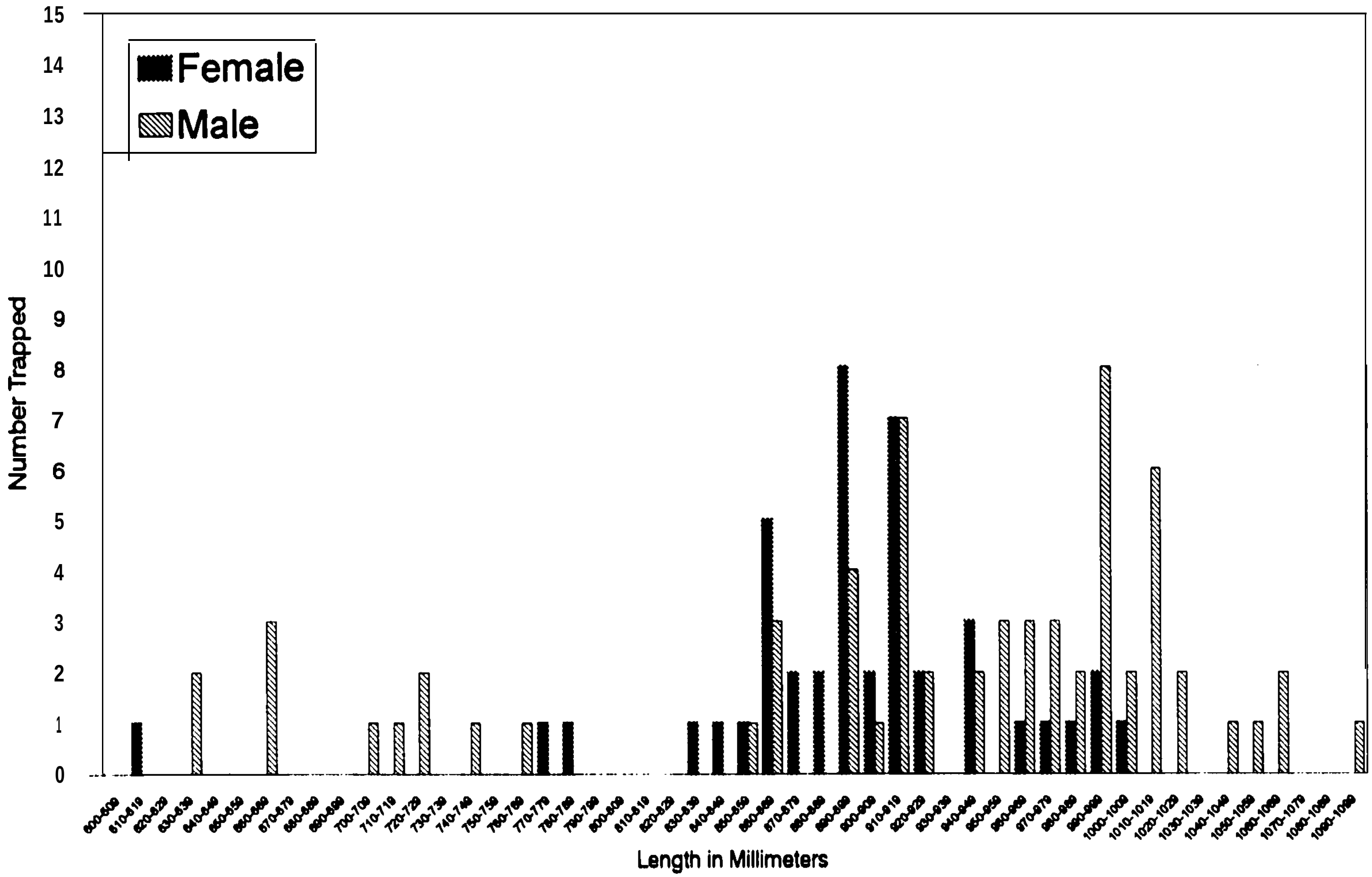
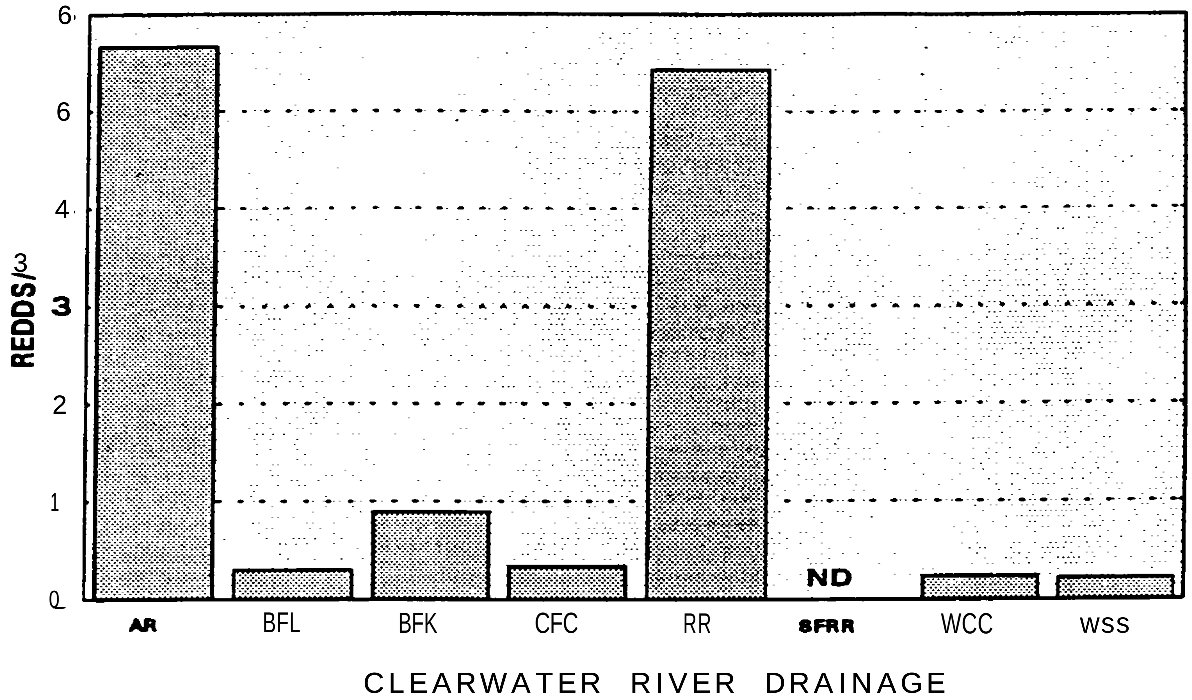


Figure 16. Length-frequency histogram of adult chinook salmon returning to Marsh Creek weir, summer 1993.



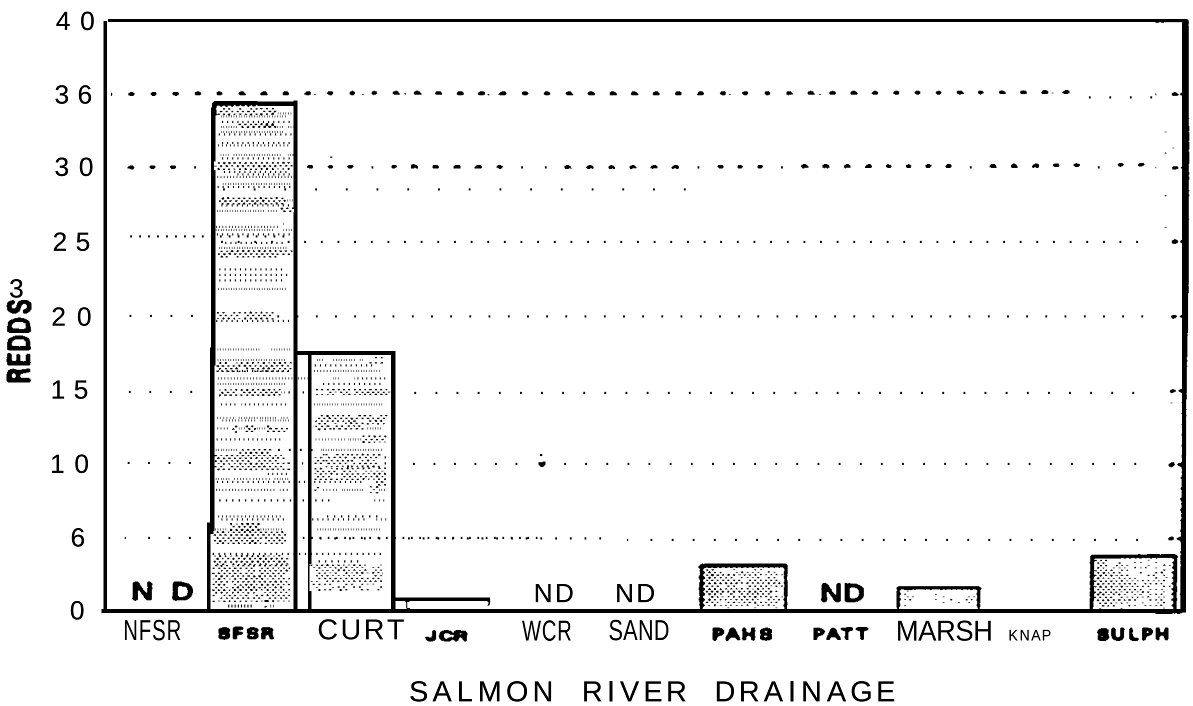


Figure 17. 1993 Chinook salmon redd counts in ISS study streams.

Table 16. Number of chinook salmon redds in ISS streams in 1992 and 1993.

Stream	Number of redds	
	1992	1993
Johnson Creek	11	44
Pahsimeroi River	32	63
Marsh Creek’	66	47
Sulphur Creek	1	a4
N.F. Salmon River	ND	ND
South Fork Salmon River[b]	454 [c]	694 [c]
American River	5	209[d]
Big Flat Creek	a	3
Brushy Fork Creek”	7	25
Crooked Fork Creek‘	13	13
Red River	44	69
White Cap Creek	2	6
White Sand Creek	3	2

[a] Includes Knapp Creek.
[b] Includes Curtis Creek.
[c] 100 pairs of adult chinook salmon were outplanted in Stolle Meadows.
[d] 165 pairs of adult chinook salmon were outplanted from Rapid River Hatchery.
[e] Includes Spruce Creek.
[f] Includes Hopeful Creek.

Table 17. ISS related chinook salmon outplants 1993.

Tributary	Number	Life stage	Fin Clip Number	Fin Clip Type	Number Pit Tagged	Release Date	Brood Stock (Adult Collection Site)	Rearing Facility
Pahsimeroi River	83953[a]	Smolt	a3953	LV	0	04/l 4	Pahsimeroi	Pahsimeroi
Upper Salmon (Above Weir)	51900	Smolt	51900	RV	800	04/20	Sawtooth	Sawtooth
East Fork Salmon River	335 17	Smolt	33517	LV	350	04/20	East Fork Salmon River	Sawtooth
South Fork Salmon River	155000[b]	Smolt	155000	RV	500	04/21	South Fork Salmon River	McCall
Squaw Creek	12000	Parr	12000	LV	1000	08/05	Powell	Clearwater
Pete King Creek	12000	Parr	12000	LV	1000	08/06	Powell	Clearwater
White Sand Creek	7998	Parr	7998	LV	1000	08/06	Powell	Clearwater
Big Flat Creek	40875	Parr	40875	LV	1000	08/07	Powell	Clearwater
Red River	21000	Pre-smolt	21000	RV	1000	10/12	Red River	Clearwater

[a] Part of a total release of 375,060 smolts of which 600 were PIT tagged. The 93,953 were those dedicated to the supplementation program.

[b] Part of a total release of 607,800 smolts of which 5,500 were PIT tagged. The 155,000 (with 500 PIT tagged) were those dedicated to the supplementation program.

On October 12, 21,000 fish were released directly from the Red River satellite facility into Red River. These fish were progeny of the six females and seven males spawned in 1992. All were right ventral fin-clipped and 1,000 were PIT tagged.

The hatcheries in the Salmon River drainage all released smolts in mid-April. All had a percentage of the release allocated for supplementation; the supplementation fish were all marked with a ventral fin clip, and all supplementation releases had representative groups PIT tagged.

Dispersal and distribution of outplanted fish were monitored for several release groups by ICFWRU and IDFG personnel (Attachment A).

DISCUSSION

Summer Parr Abundance and PIT Tagging

In most streams, parr populations were lower than the previous two years. This generally follows the lower spawning escapement in 1992 (Leitzinger et al. 19931.

Two different methods of estimating parr populations were used. The first method uses a stratification scheme based on strata (channel type) within streams. This method was used in 1991 and 1992 (Leitzinger et al. 1993). The second method, used for the first time this year, uses a stratification scheme based on habitat types. The theory for this new method is that since fish do not equally use the various habitats, stratifying by habitat would reduce variation within the group and thus the overall variability of the estimate, resulting in smaller confidence intervals. This was not always the case. The variability of the estimate was reduced in five streams, but increased in two streams. Although estimates by habitat reduced the confidence intervals in most cases, the decreases were small. The confidence interval decreases ranged from 3.56% for Big Flat Creek to 10.25% for White Sand Creek.

A comparison of the parr population estimates from the two methods indicates that one or both of the methodologies are biased. In all cases except Sulphur Creek, the population estimates were lower by habitat than by strata. It is not clear why this happened. The differences may be due to the fact that in many streams our sampling was not representative of all habitats present. Sampling was biased toward runs and to a lesser extent pools. These are the habitats that juvenile chinook salmon are most likely to be found. Thus, our strata estimates would overestimate the population by under representing riffle and pocket water habitats. We will adjust our snorkeling this summer to accurately represent all habitats, and again compare population estimation techniques.

The ISS experimental design calls for confidence intervals within 30% of the chinook salmon estimate to maintain enough power to detect expected supplementation effects (Bowles and Leitzinger 1991). We have reached this level of precision in only one case by strata in 1993 (Marsh Creek, 27.86%), and two by habitat (Marsh Creek, 21.37% and Brushy Fork Creek, 26.05%). Other error bounds have ranged as high as 186% of the point estimate (Big Flat Creek). There are two main reasons for the large confidence intervals. First, in many cases there are too few sample sites. Second, the low seeding levels we are presently observing result in very high variation in the number of juveniles counted. Counts also vary with proximity to a redd. We hope to reduce the confidence intervals this next field season by increasing the number of sites, sampling all habitats representatively, incorporating number of redds and redd location as covariates, and calculating population estimates by habitat type again.

We did not meet our summer parr PIT tagging target (700 fish per stream) in any of the study streams. Densities of chinook salmon parr were too low to warrant PIT tagging in several streams snorkeled by the IDFG ISS crew. Also, high water and cool temperatures kept chinook salmon parr growth rates low. In several streams, many of the juveniles captured were too small to PIT tag. PIT tagging mortality was nonexistent. All PIT tagged fish were kept in live wells for 24 hours after tagging before being released to quantify tagging related mortality.

PIT Tag Detections

The first complete PIT tagged brood year (BY 91) in this study migrated to the ocean the spring of 1993. Among these migrants were fish tagged as summer Parr, fall outmigrants, and spring smolt outmigrants. Detection information did not reveal any major surprises. As expected, the greater the time between tagging and outmigration, the lower the detection rate. Also, hatchery releases had lower detection rates than their wild/natural counterparts. Fall released hatchery fish had particularly low detection rates. These fall releases are known to move out of the release streams immediately after release (as demonstrated at our traps). Fall releases of hatchery reared chinook salmon from the Hayden Creek research station during the 1970s were observed in the Snake River one to two months after release (Reingold 1971, 1973a, 1973b; Anderson 1978). One possible reason for the low detection rates for these fish is that many of them may have moved past the dams in the fall when the detection facilities are not operating. Also, it is interesting to note that in Crooked Fork Creek the few fail releases that overwintered upstream of our traps and migrated in the spring had similar detection rates to the wild/natural fish. This data should be interpreted cautiously because the sample sizes are very low.

Spring and Fall Emiarants and PIT Tagging

Spring

The spring 1993 emigration cues are not as clear as in fall 1992 (Leitzinger et al. 1993). During the spring, smolts migrated past our traps prior to the high water. There still appears to be a connection between movement and lunar phase, but other factors such as warming water temperatures may also be playing a part. In some cases there were migration peaks during the full moon. It is difficult to interpret this because these peaks were small. As other projects become fully implemented (e.g. steelhead supplementation) we will have thermograph data for all of our trap sites. At present, we have water temperature data for Marsh Creek only. That data still needs to be retrieved and analyzed.

We did not meet our target of PIT tagging 500 spring smolts at any trap except Red River. Delays in obtaining our NMFS collecting permit prevented us from installing our three Salmon River traps until early April. Based on our trapping results for those three traps, it is clear that the majority of the chinook salmon overwintering in those headwater areas had migrated prior to the first of April. The Red River and Crooked Fork Creek traps were installed in mid-March. The majority of chinook salmon smolts trapped and tagged at those locations were trapped before April first. It appears that the spring 1993 outmigration peaked early to mid-March, prior to the start of our trapping.

One surprise was our trapping (in some cases large numbers) of emergent chinook salmon fry, many still with yolk sacs. There is no clear indication as to why these fry appeared when they did. There is no pattern with respect to flow. It may strictly be downstream drift of newly emerged fry, with the numbers trapped being greater for those traps closer to the spawning areas. It may also be a time of spawning/water temperature/elevation response. Marsh Creek fry appeared early in the trapping season, and peaked prior to high water. Marsh Creek is the highest elevation trap (1,984 m), open meadow (i.e. relatively warm in summer and fall) stream. The trap is very close to the spawning grounds. The South Fork Salmon River is second highest in elevation (1,554 m), but colder (as shown by much smaller parr throughout the summer and fall outmigration). Fry appeared in the middle of the trapping season and peaked as water levels rose. Fry numbers remained high throughout the remainder of the trapping season (after the high water).

The trap is also located very close to chinook salmon spawning areas. Fry in Red River started appearing in the trap late in the trapping season, as water levels began to rise. The trap was located roughly 100 m upstream of the mouth, 10 km from the nearest major spawning area. Red River is a low elevation stream (1 ,189 m at the trap). Crooked Fork Creek is the lowest elevation stream (1,055 m). Fry did not start showing up in the trap (located = 4-5 km upstream of the mouth) until after the peak in the hydrograph. The majority of fry were trapped as water levels were declining. The trap is located roughly 9-10 km below the major spawning ground. Fry also started appearing in the Pahsimeroi River trap late in the season (mid-May).

The Pahsimeroi River is intermediate in elevation (1,420 m) but warmest of the five streams with traps. It is also the most productive because it is spring fed. These characteristics may limit or delay fry movement. This is evident because the fry trapped in the Pahsimeroi were large enough to PIT tag (over 60 mm fork length), whereas in all the other streams, they had not even absorbed their yolk sacs. Based on this, it appears that fry movement occurs immediately after emergence in all the streams except the Pahsimeroi. Also, the Pahsimeroi does not have a spring runoff. Snowmelt is diverted from the Pahsimeroi for irrigation. While other streams are experiencing high water from snowmelt, the Pahsimeroi River's flow usually decreases. We do not know what effect this has, if any, on juvenile chinook salmon movement.

Trapping efficiencies were lower than observed in fall 1992 and fall 1993 seasons. The lower efficiencies were due to trapping in higher water and flows, which reduce the percent of the flow sampled.

Fall

In most cases, fall outmigration appeared to be related to lunar phase. Specifically, outmigration peaks were associated with the new moon. Doty (1969) had similar findings with juvenile steelhead released from the Hayden Creek Research Station in the Lemhi River drainage, Idaho. The one major exception we found to this was Marsh Creek. The largest peak in outmigration occurred during a full moon. This indicates that other factors are also important, such as decreasing temperature. Perhaps there is a threshold temperature that must be reached before large numbers of outmigrants will be seen. This, at least superficially, is supported by the outmigration timing in the Pahsimeroi. We do not trap large numbers of outmigrants in the Pahsimeroi River until late November and December, well after the outmigration has mostly stopped in the other streams. We will continue to evaluate the association between these cues and outmigration. Hopefully, this information will help improve the success of supplementation releases. Other researchers (Hopkins 1991) have found increased survival to adult of chinook salmon smolts released just prior to the new moon.

Trap efficiencies were relatively high for all traps except the Pahsimeroi River (efficiency estimate = 3.18% for escaped hatchery fish and 9.24% for natural fish). High efficiencies are expected in the fall because of low, stable water conditions. The low trap efficiency in the Pahsimeroi is due to the stream characteristics. The Pahsimeroi River is a low gradient, relatively warm, deep, and productive spring fed stream. Because of the depth, the relative percent of the stream that is being fished is less than the others. Additionally, it is a much less harsh environment than the high elevation batholith streams. This also may result in the later outmigration timing for these fish. We speculate that some of the trapped fish released above the trap (to estimate trap efficiency): 1) did not continue their migration and overwintered above the trap; or 2) moved at a much slower rate, thus passed the trap site after the trap was removed.

We met our fall emigrant PIT tag target (700 fish per stream) in all of the streams except the Pahsimeroi River (total tagged = 596). We installed the traps earlier than in 1992. We were able to trap and PIT tag the early migrants, unlike the fall of 1992 and the spring of 1993. The relatively low number of fish tagged in the Pahsimeroi can be explained by the stream characteristics listed above and by the late outmigration timing of these fish. We have been forced to pull the trap in mid-December because low air temperatures cause the trap to freeze at night and stop working. This happens to be the same time when fish in the Pahsimeroi are actively migrating. PIT tag mortality was low (less than 1%) on all traps.

When comparing summer parr estimates to fall outmigration estimates, it is clear that the majority of fish emigrate from these headwater spawning and rearing areas in the fall. Assuming no mortality between snorkeling and outmigration, between 63% and 97% of the parr moved in the fall in Crooked Fork Creek (including Brushy Fork Creek) and the Pahsimeroi River (depending on population estimate used). In Marsh Creek, the estimated fall outmigrants greatly outnumber the summer parr estimates. In fact, we trapped more fish (9,652) than our population estimate by habitat type (6,822). We trapped 97.5% of our estimated population by strata. It is ironic that Marsh Creek is the one stream where we have consistently had confidence intervals on our population estimates of less than 30% of the estimate. All of the outmigration estimates do not include those fish that left prior to our trapping or after the trap was pulled. The actual number of outmigrants is likely greater than our estimates. Obviously, there are biases associated with our snorkeling estimates. Snorkeling estimates underestimate parr populations. Hopefully, the adjustments planned for the 1994 field season will rectify this problem. It is also possible that the outmigration estimates are high. The outmigration estimates are unstratified total estimates based on trap efficiencies. More detailed estimates taking into account flow, lunar phase, or specific time periods will be done in the future.

Spawning Escapement

Weirs

The Marsh Creek weir worked effectively for adult chinook salmon after some modification. The main problem was the location of the adult holding box. It previously was on the downstream side of the weir associated with one of the abutments. There was not enough attraction water to direct the fish straight into the live box. We installed pickets from the downstream corner of the live box diagonally downstream to the far bank. This was quite effective in guiding the fish directly into the trap. The live box has been modified for the 1994 adult salmon trapping season. It is larger, and it sits on the upstream side of the weir in the middle of the stream in deeper, calmer water. It has a trap door on the upstream side that can be lifted to allow the fish to continue their migration without being handled.

The original trap did not work for trapping adult steelhead. We will try to trap adult steelhead with the new live box in the spring of 1994.

A temporary weir has been built for Crooked Fork Creek. It will be used in 1994 to collect local broodstock for supplementation in Crooked Fork Creek. The ISS experimental design (Bowles and Leitzinger 1991) calls for using progeny from adult chinook salmon returning to Crooked Fork Creek to supplement Crooked Fork Creek (i.e. a local broodstock). Progeny from the brood year 1994 adults are planned to be released into Crooked Fork Creek in the fall of 1995.

Redd Counts

Numbers of redds counted were generally greater in 1993 than the previous two years. This is the result of relatively good outmigration conditions in the spring of 1990. Most of the adults and carcasses seen were five year old fish. We did not see a second group of late spawning fish like we did in several streams in 1992. This may be due to better upstream migration conditions in 1993. Also, the fish moved farther upstream to spawn than they had in previous years. There was more water in the streams in 1993 than in the previous seven drought years.

Broodstock Collection

Due to better adult returns in 1993, more fish will be available for supplementation in 1994 and 1995. All treatment streams should receive some outplants.

For the second straight year, 100 pairs of surplus adults returning to the South Fork Salmon River weir were trucked to the headwaters to spawn in their historic spawning area (Stolle Meadows). These fish were in addition to those normally passed at the weir. Also, 165 pairs of surplus Rapid River Hatchery adults were trucked to American River to spawn.

Rearing, Marking, and Releases

Fish husbandry, marking, and releases of supplementation fish went smoothly during initial implementation of the supplementation program. Outplanting parr in upper White Sand Creek and Big Flat Creek went without a problem this year. Smolt releases into the upper Salmon, East Fork Salmon, South Fork Salmon, and Pahsimeroi rivers all went smoothly. There was one coordination lapse during the South Fork Salmon River release that led to the death of approximately 350 hatchery chinook salmon smolts in our trap. The problem was quickly remedied and should not happen again.

CONCLUSIONS

Chinook salmon parr population estimation remains the weak link in the program. Confidence intervals are still too large. Snorkeling has underestimated parr populations. Partitioning out variability by habitat type may not prove to be beneficial. More is needed before solid conclusions can be drawn. However, determining the habitat composition of the streams was very worthwhile because it pointed out where the "holes" or major sources of bias and variation are in our snorkeling. Now we can take steps to fill those gaps and eliminate that bias.

Outmigration cues need to be analyzed to determine what environmental cues trigger chinook salmon outmigration. The relationship between water temperature needs to be (and will be this next year) further explored. This information could help plan stocking to maximize survival of outmigrating hatchery chinook salmon.

PIT tagged wild/natural chinook salmon had higher detection rates at the dams than did their hatchery counterparts. Whether or not this translates to better survival to returning adult or is just an indication of better fitness of wild/natural stocks will not be seen for several more years. More information is needed on movements of fall hatchery releases (and perhaps summer parr as well) in order to explain their low detection rates at the dams.

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A P P E N D I C E S

Appendix A. Standardized snorkeling techniques to be used in Idaho Supplementation Studies.

Methods;

- **The number of snorkelers depends on visibility and width of the stream.**

- **Snorkelers move slowly but steadily upstream in an assigned lane. The widths of the lanes are determined by visibility. The snorkelers are not in a single line perpendicular to the stream. Instead, they are staggered. For example, if there are five snorkelers, one snorkeler will be close to each bank and counting fish between themselves and the banks. The next two divers will be slightly downstream (l-3 m depending on visibility) and closer to the center of the stream. They count the fish that swim between themselves and the diver closest to the bank on their side. The final diver is in the middle of the stream downstream of the other four and counts all the fish the swim between the two divers and swim past them. In essence, the divers form a "V" in the stream. It is important that they maintain proper positioning in their respective lanes in order to maintain accuracy of the counts.**

- **Field crews are trained prior to each field season in snorkeling techniques, fish identification, and size estimation. Calibrated dowels are carried by novices for more accurate size estimation.**

- **Visibility is measured prior to snorkeling (with an orange and white nylon measuring tape held underwater) to insure that visibility is sufficient to allow accurate counts. In most streams, visibility is >3 m.**

- **Snorkeling is done in daylight hours, after streams temperatures have risen above 8-C. Juvenile salmonids have shown to conceal themselves when water temperatures drop to or below this level (Hillman et al., in press; Reihle 1990).**

- **Chinook salmon are identified and counted as YOY, yearlings, or adults. All other salmonids are identified and lengths are estimated to the nearest inch. After several fish have been counted by an individual, he tells the data recorder walking on the bank behind the snorkelers. The recorder draws detailed sketch maps of the snorkeling reach, noting major habitat types, easily recognizable features of the surrounding land, etc. This person also gives detailed directions to the site, the starting and ending points, presence of flagging, and any other information that may be of value in locating the sites in the future. If a recorder is not available, all is recorded on plexiglass slates carried by the divers.**

Appendix 6. ISS parr population estimates by strata and chinook salmon densities, summer 1993. The number in parentheses represents the error bound as a percent of the population **estimate.**

Stream	**Strata (from - to)**	**Number section**	**Chinook population estimate**	**90% C.I.**	**Observed density #/100 m^2**
Salmon River Drainage					
Pahsimeroi River	1 (Mouth - Hooper Lane)	29	6,840	6,564	1.85
Total	**All Strata**	**29**	6,840	6,564 (95.97)	1.85
Marsh Creek	2 (Weir - Knapp Creek)	21	6,529	2,262	13.85
	1 (Knapp Creek - Headwaters)	10	2,997	1,759	14.74
Knapp Creek	1 (Mouth - Headwaters)	10	373	348	0.28
Total	**All Strata**	**41**	**9,899**	2,758 (27.86)	10.56
Sulphur Creek	2 (Mouth - North Fork Sulphur Creek)	24	28	33	0.02
	1 (North Fork Sulphur Creek - Headwaters)	9	0	0	0
North Fork Sulphur Creek	1 (Mouth - Headwaters)	4	0	0	0
Total	**All Strata**	37	28	32 **(114.291**	0.01
Upper Salmon River	10 (River Km 647 - 6,700 M Upstream)	3	0	0	0
	9 (River Km 642 - 5,100 M Upstream)	2	0	0	0
	8 (River Km 639 - 4,900 M Upstream)	2	0	0	0
	8 (Side Channel)	2	0	0	0
	7 (River Km 633 - 7,900 M Upstream)	2	0	0	0
	7 (Side Channel)	2	0	0	0
	6 & 5 (River Km 628 - 6,400 M Upstream)	4	57	81	0.04
	6 & 5 (Side Channels)	2	0	0	0
	4 & 3 (River Km 615 - 16,100 M Upstream	7	984	1,643	12.23
	4 & 3 (Side Channels)	4	4,833	8,629	12.23

Appendix 8. Continued.

Stream	Strata (from - to)	Number section	Chinook population estimate	90% C.I.	0 bserved density #/100 m^2
Salmon River Drainage					
Smiley Creek	2 (Top of 1b - 7,600 M Upstream)	3	0	0	0
	1b (Top of 1a - 3,600 M Upstream)	5	322	364	1.56
	1a (Mouth - 2,100 M Upstream)	2	21	130	0.16
Pole Creek	5 (Top of 4 - 1,400 M Upstream)	2	-	-	-
	4 (Top of 3 - 4,500 M Upstream)	2	-	-	-
	3 (Top of 2 - 3,100 M Upstream)	2	0	0	0
	2 (Top of 1 - 5,000 M Upstream)	3	0	0	0
	1 (Mouth - 2,600 M Upstream)	3	0	0	0
Petit Lake Creek and Yellowbelly Lake Creek	1 (P.L.C. Mouth - 2,000 M Upstream; Y.L.C. Mouth - 1,300 M Upstream)	3	911	2,159	2.87
Huckleberry Creek	2 (Top of 1 - 1,400 M Upstream)	2	-	-	-
	1 (Mouth - Decker Flat Road)	2	0	0	0
Gold Creek	2 (Top of 1 - 1,500 M Upstream)	2	-	-	-
	1 (Mouth - 1,300 M Upstream)	2	0	0	0
Frenchman Creek	2 (Top of 1 - 6,300 M Upstream)	5	11,500	1,972	4.59
	1 (Mouth - 1,100 M Upstream)	2	33	198	1.03
Champion Creek	2 (Top of 1 - 3,100 M Upstream)	2	0	0	0
	1 (Mouth - 2,800 M Upstream)	4	123	94	1.99

Appendix B. Continued.

Stream	Strata (from - to)	Number section	Chinook population estimate	90% C.I.	Observed density #/100 m^2
Fourth of July Creek	2 (Top of 1 - 5,500 M Upstream)	2	-		
	1 (Mouth - 3,500 M Upstream)	2	0	0	0
Beaver Creek	2 (Top of 1 - 4,400 M Upstream)	2	0	0	0
	1 (Mouth - 3,000 M Upstream)	2	0	0	0
Salmon River Drainage					
Williams Creek	1 (Mouth - 2,800 M Upstream)	3	245	696	5.35
Total	**All Strata**	77	19,029	212 (1.11)	Na
Alturas Lake Creek	5 (Top of 4 - 7,700 M Upstream)	2	0	0	0
	4 (Top of 3 - 6,200 M Upstream)	2	0	0	0
	3 (Top of 2 - 2,300 M Upstream)	3	233	255	1.05
	2 (Top of 1 - 1,700 M Upstream)	2	360	1,813	1.26
	1 (Mouth - 2,600 M Upstream)	3	0	0	0
Total	**All Strata**	12	593	86' (14.5)	Na

Appendix B. Continued.

Stream	Strata (from - to)	Number section	Chinook population estimate	90% C.I.	Observed density #/100 m^2
Clearwater River Drainage					
Crooked Fork Creek	4 (Mouth - Brushy Fork Creek)	13	3,865	1,864	0.93
	3 (Brushy Fork Creek - Boulder Creek)	9	6,860	6,128	3.70
	2 (Boulder Creek - Hopeful Creek)	5	0	0	0
	1 (Hopeful Creek - Headwaters)	3	0	0	0
Hopeful Creek	1 (Mouth - Headwaters)	3	0	0	0
Total	**All Strata**	33	**10,725**	5,880 **(54.83)**	1.59
Brushy Fork Creek	3 (Mouth - Pestle Rock)	9	410	268	0.52
	2 (Pestle Rock - Barrier)	19	2,418	1,085	1.61
Spruce Creek	1 (Mouth - Headwaters)	2	0	0	0
Total	**All Strata**	30	2,828	**1,093 (38.65)**	**1.24**
Big Flat Creek	1 (Mouth - Headwaters)	8	95	177	0.08
Total	**All Strata**	8	95	177 (186.32)	0.08
White Sand Creek	1 (Big Flat Creek - Headwaters)	18	46	54	0.03
Total	**All Strata**	18	46	54 **(117.39)**	0.03

Appendix B. Continued.

Stream	Strata (from - to)	Number section	Chinook population estimate	90% C.I.	Observed density #/100 m²
Clearwater River Drainage					
Crooked River	4 (Top of 3 - Canyon Section)	3	1,031	1,854	3.09
	3 (Mouth - Meander Section)	3	3,254	5,251	11.35
	2 (Top of Canyon - Crooked River Road Bridge)	4	4,390	3,546	11.19
	1 (Top of 2 - 400 Yards Upstream of 5 Mile Creek)	6	466	370	1.25
	Canyon (All of Canyon Section)	3	5,793	15,086	9.36
	Headwaters Strata	1	0	0	0
	Pond a	3	1,955	1,733	53.43
	Pond B	3	6,417	17,924	31.69
Relief Creek	2 (Top of 1-Confluence of E. And W. Fork)	2	0	0	0
	1 (Mouth - 1,000 M Upstream)	3	999	1,515	17.97
Five Mile Creek	1 (Mouth - 250 M Upstream)	2	5	22	0.7
Total	**All Strata**	**33**	**24,310**	**373[a] (1.53)**	**na**

[a] The Upper Salmon River, Alturas Lake Creek, and Crooked River population estimates were made using Intensive Smolt Monitoring data (R. Kiefer, unpublished data).

Appendix C. ISS chinook salmon parr population estimates and densities, by habitat type, summer 1993. The number in parentheses represents the error bound as a percent of the population estimate.

Salmon River Drainage						
Stream	**Habitat**	**Strata (from-to)**	**Number section**	**Chinook population estimate**	**90% C.I.**	**Observed density #/100m^2**
Pahsimeroi River	Pool	1 (Mouth-Hooper Lane)	14	1,094	1,516	5.49
	Riffle		4	2,555	8,307	10.01
	Run		24	2,281	3,023	0.72
Total	All		42	5,930	6,804 (114.74)	1.93
Marsh Creek	Pool	2 (Weir-Knapp Creek)	11	1,861	907	28.67
	Riffle		10	1,369	801	14.63
	Run		18	2,007	717	10.06
	All		39	5,237	1,320	14.00
Marsh Creek	Pool	1 (Knapp Creek-headwaters)	5	219	107	27.35
	Riffle		3	133	381	3.01
	Run		9	957	622	9.42
	All		17	1,309	638	14.54
Knapp Creek	Pool	1 (Mouth-headwaters)	1	0	0	0
	Riffle		2	0	0	0
	Run		9	276	246	0.31
	All		12	276	242	0.28
Total	All	All Strata	68	6,822	1,458 (21.37)	10.63
Sulphur Creek	Pool	2 (Mouth-North Fork Sulphur Creek)	4	35	81	0.07
	Riffle		6	0	0	0
	Run		19	6	10	0.01
	Pocket Water		3	0	0	0
	Glide		2	0	0	0
	All		34	41	59	0.02
	Pool	1 (North Fork Sulphur Creek-headwaters)	2	0	0	0
	Riffle		3	0	0	0
	Run		4	0	0	0
	Pocket Water		3	0	0	0
	Glide		1	0	0	0
	All		13	0	0	0
Total	All	All Strata	47	41	59 (143.90	0.01

Appendix C. Continued.

Stream	Habitat	Strata (From-to)	# Sections	Chinook Pop. Estimate	90% C.I.	Observed Density #/100m²
Clearwater River Drainage						
Big Flat Creek	Pool	1 (Mouth-headwaters)	0			
	Riffle		0			
	Run		8	29	53	0.08
	Pocket Water		0			
Total	All		8	29	53 (182.76)	0.08
White Sand Creek	Pool	1 (Big Flat Creek-headwaters)	1	0	0	0
	Riffle		0			
	Run		16	14	15	0.04
	Pocket Water		1	0	0	0
Total	All		18	14	15 (107.14)	0.03
Brushy Fork Creek	Pool	3 (Mouth-Pestle Rock)	0	-	-	-
	Riffle		1	0	0	0
	Run		0	-	-	-
	Pocket Water		8	275	171	0.59
	All		9	275	171	0.52
Brushy Fork Creek	Pool	2 (Pestle Rock-barrier)	3	404	293	4.97
	Riffle		7	480	370	1.50
	Run		11	520	246	0.77
	Pocket Water		1	91	-	0.41
	All		22	1,495	442	1.62
Spruce Creek	Pool	1 (Big Flat Creek-headwaters)	0			
	Riffle		0			
	Run		2	0	0	0
	Pocket Water		0			
	All		2	0	0	0
Total	All	All Strata	33	1,770	461 (26.05)	1.24
Crooked Fork Creek	Pool	4 (Mouth-Brushy Fork Creek)	2	33	52	1.77
	Riffle		3	616	1,769	0.50
	Run		5	2,470	1,627	1.60
	Pocket Water		3	196	445	0.20
	All		13	3,315	1.808	0.93

Appendix C. Continued.

Clearwater River Drainage Cont.						
Stream	Habitat	Strata (From-to)	# Sections	Chinook Pop. Estimate	90% C.i.	0 bserved Density #/100m²
Crooked Fork Creek (Cont'd)	Pool	3 (Brushy Fork Creek-boulder Creek)	2	27	19	0.43
	Riffle		2	1,954	6,424	2.88
	Run		5	3,653	4,596	6.1 1
	Pocket Water		0			
	All		9	5,634	4,632	3.70
Crooked Fork Creek	Pool	2 (Boulder Creek-hopeful Creek)	0	-	-	-
	Riffle		0	-	-	-
	Run		4	0	0	0
	Pocket Water		1	0	0	0
	All		5	0	0	0
Crooked Fork Creek	Pool	1 (Hopeful Creek-Headwaters)	0	-	-	-
	Riffle		0	-	-	-
	Run		3	0	0	0
	Pocket Water		0	-	-	-
	All		3	0	0	0
Hopeful Creek	Pool	1 (Mouth-headwaters)	0	-	-	-
	Riffle		0	-	-	-
	Run		3	0	0	0
	Pocket Water		0	-	-	-
	All		3	0	0	0
Total	All	All Strata	33	8,949	4,429 (49.49)	1.59

Appendix D. Salmon and Clearwater River chinook ealmon redd count summary, 1993.

SALMON RIVER DRAINAGE								
TRIBUTARY	STRATA	COUNT METHOD	DATE	# REDDS (POSS.)	DOWNSTREAM	UPSTREAM	MALE (mm FL)	FEMALE (mm FL)
JOHNSON CREEK	I	GROUND	8/26/93 B/27/93	25	BURNT LOG TRAIL CROSSING (TOP OF CANYON)	BOULDER CR.	950 960 1050 660	890 840 870 BOO 890
	I	GROUND	9/2/93 9/7/93	11	BURNT LOG TRAIL CROSSING (TOP OF CANYON)	BOULDER CR.	890 840	910 840 860 840
	I	GROUND	9/22/93 9/26/93	B	BURNT LOG TRAIL CROSSING (TOP OF CANYON)	BOULDER CR.		790 910
TOTALS				44			6@890	11@860 (+1*)

MARSH CREEK	III	GROUND	8/18/93	0	MOUTH OF CAPE HORN CR.	WEIR	6 @ $\bar{X}$=945	
	II	GROUND	B/18/93	34	WEIR	MOUTH OF KNAPP CR.	11 @ $\bar{X}$=990	22 @ $\bar{X}$=850
	I	GROUND	B/19/93	2	MOUTH OF KNAPP CR.	DRY CR.		
	III	GROUND	B/24/93	2(1)	MOUTH OF CAPE HORN CR.	WEIR		
	II	GROUND	8/20/93 and 8/30/93	0	WEIR	MOUTH OF KNAPP CR.	2 @ $\bar{X}$=1020	4 @ $\bar{X}$=890
	I	GROUND	9/15/93	0(5)	MOUTH OF KNAPP CR.	DRY CR.		
	III	GROUND	9/15/93	0	MOUTH OF CAPE HORN CR.	WEIR		
	II	GROUND	9/2/93	1	WEIR	MOUTH OF KNAPP CR.		2 @ $\bar{X}$=910
	I	GROUND	9/26/93	0	MOUTH OF KNAPP CR.	DRY CR.		

Appendix D. Continued.

SALMON RIVER DRAINAGE

TRIBUTARY	STRATA	COUNT METHOD	DATE	# REDDS (POSS.)	DOWNSTREAM	UPSTREAM	MALE (mm FL)	FEMALE (mm FL)
MARSH CREEK	II	GROUND	9/15/93	3	WEIR	MOUTH OF KNAPP CR.		
TOTALS				42(6)			19@980	28@860
							(+4[a]+1[b]+1[c])	
KNAPP CREEK	I	GROUND	8/19/93	5	MOUTH	MEADOW		
	I	GROUND	8/31/93	0(1)	MOUTH	1.4 MILES UPSTREAM FROM MOUTH		
	I	GROUND	9/15/93	0(1)	MOUTH	1.4 MILES UPSTREAM FROM MOUTH		
TOTALS				5(2)				
PAHSIMEROI RIVER	I	GROUND	8/25/93 8/30/93 9/2/93 9/3/93	11	MOUTH	P11 SCREEN		
	I	GROUND	9/27/93 9/28/93 10/4/93	51	MOUTH	P11 SCREEN	940 520	890
	I	GROUND	10/21/93	1	MOUTH	PSA SCREEN		
TOTALS				63			2@730	1@890
							(+1[a])	
SOUTH FORK SALMON RIVER (5 PASSES)	III	GROUND	9/10/93 thru 10/8/93	306	WEIR	WARM LAKE TURNOFF	47 @ x=860	137 @ x=880
	II	GROUND		326	WARM LAKE TURNOFF	RICE CR.		
	I	GROUND		34	RICE CR.	1000 METERS UPSTREAM OF VULCAN HOT SPRINGS TRAIL		
TOTALS				666			47@860	137@880

Appendix D. Continued.

SALMON RIVER DRAINAGE

TRIBUTARY	STRATA	COUNT METHOD	DATE	# REDDS (POSS.)	DOWNSTREAM	UPSTREAM	MALE (mm FL)	FEMALE (mm FL)
CURTIS CREEK	I	GROUND	8/31/93	28	MOUTH	1 ROAD MILE UPSTREAM		
TOTALS				28				

SULPHUR CREEK	II	GROUND	9/16/93	44(1)	FOOTBRIDGE WHERE SULPHUR CR. TRAIL CROSSES SULPHUR CR.	APPROXIMATELY 200 METERS UPSTREAM OF SULPHUR CR. RANCH		
	II	GROUND	9/15/93	40(1)	APPROXIMATELY 200 METERS UPSTREAM OF SULPHUR CR. RANCH	NORTH FORK SULPHUR		
	I	GROUND	9/14/93	0	NORTH FORK SULPHUR	SMALL TRIB. UPSTREAM FROM "MEADOW" SNORKEL SITE		
TOTALS				84(2)				(+2[a]+3[b])

CLEARWATER RIVER DRAINAGE

AMERICAN RIVER	III	GROUND	8/25/93	12	MOUTH	BOX SING CR.	1 @ $\bar{x}$=960	4 @ $\bar{x}$=810
	II	GROUND	8/26/93	40(4)	BOX SING CR.	UNNAMED TRIB. JUST UPSTREAM OF "LOWER GRAVEL PILE" SNORKEL SITE	2 @ $\bar{x}$=925	3 @ $\bar{x}$=790
	I	GROUND	8/27/93 and 8/29/93 thru 9/1/93	113(5)	UNNAMED TRIB. JUST UPSTREAM OF "LOWER GRAVEL PILE" SNORKEL SITE	LONG MEADOW (BETWEEN 2ND AND 3RD PERMANENT TRIBS. ABOVE LIMBER LUKE CR.)	43 @ $\bar{X}$=850	26 @ $\bar{X}$=800
	III	GROUND	9/20/93 and 9/28/93	7	MOUTH OF AMERICAN R.	BOX SING CR.		

Appendix D. **Continued.**

CLEARWATER RIVER DRAINAGE								
TRIBUTARY	STRATA	COUNT METHOD	DATE	# REDDS (POSS.)	DOWNSTREAM	UPSTREAM	MALE (mm FL)	FEMALE (mm FL)
AMERICAN RIVER	II	GROUND	9/28/93	13(1)	BOX SING CR.	UNNAMED TRIB. JUST UPSTREAM OF "LOWER GRAVEL PILE" SNORKEL SITE		
	I	GROUND	9/29/93	24	UNNAMED TRIB. JUST UPSTREAM OF "LOWER GRAVEL PILE" SNORKEL SITE	APPROXIMATELY 0.5 MILES ABOVE LIMBER LUKE CR.		
TOTALS				209(10)			468860	338800
							(+8[a]+5[b]+11[c])	
BIG FLAT CREEK	I	GROUND	9/2/93	2	MOUTH	APPROXIMATELY 0.25 MILES UPSTREAM FROM THE "UPPERMOST" SNORKEL SITE		850
	I	GROUND	10/7/93	1	MOUTH	APPROXIMATELY 0.25 MILES USTREAM FROM THE "BIG HOLE" SNORKEL SITE		
TOTALS				3				1@850
BRUSHY FORK CREEK	V; IV	GROUND	8/31/93	16(1)	MOUTH	TWIN CR.	1040 920 930 890 960	850 710 840
	III	GROUND	9/14/93	0	TWIN CR.	.2 SNORKEL SITE (TREND AREA)		
	III	GROUND	9/8/93	1(2)	BRIDGE ABOVE TREND AREA	MIGR. BARRIER		
	V; IV	GROUND	10/12/93	1(1)	MOUTH	TWIN CR.		
	III	GROUND	10/11/93	0	TWIN CR.	.2 SNORKEL SITE (TREND AREA)		

Appendix D. Continued.

CLEARWATER RIVER DRAINAGE								
TRIBUTARY	STRATA	COUNT METHOD	DATE	# REDDS (POSS.)	DOWNSTREAM	UPSTREAM	MALE (mm FL)	FEMALE (mm FL)
BRUSHY FORK CREEK	III	GROUND	9/29/93	5(2)	.2 SNORKEL SITE (TREND AREA)	BRIDGE ABOVE TREND AREA	840	710 810 820
	III	GROUND	10/9/93	0	BRIDGE ABOVE TREND AREA	MIGR. BARRIER		
TOTALS				23(6)			6@930	6@790
							(+1[a]+4[c])	
SPRUCE CREEK	I	GROUND	9/9/93	2(1)	MOUTH	1 MILE ABOVE MOUTH		850 820
	I	GROUND	10/9/93	0	MOUTH	1 MILE ABOVE MOUTH		
TOTALS				2(1)				28835
							(+1[b])	
CROOKED FORK CREEK	IV	GROUND	8/26/93 8/29/93 8/30/93	3(2)	MOUTH	MOUTH OF BRUSHY FORK		
	III	GROUND	9/10/93	1	MOUTH OF BRUSHY FORK	MOUTH OF ROCK CR.		
	III	GROUND	9/11/93	0	SHOTGUN CR.	BOULDER CR.		
	II	GROUND	9/15/93	0	BOULDER CR.	HOPEFUL CR.		
	I	GROUND	9/13 J93	0	HOPEFUL CR.	UPPERMOST SNORKEL SITE		
	IV	GROUND	9/20/93 thru 9/22/93	1(2)	MOUTH	MOUTH OF BRUSHY FORK		
	III	GROUND	10/3/93	1	MOUTH OF BRUSHY FORK	MOUTH OF ROCK CR.		
	III	GROUND	10/8/93 10/20/93	7	MOUTH OF ROCK CR.	BOULDER CR.		
	II	GROUND	10/5/93 10/6/93 10/8/93	0	BOULDER CR.	HOPEFUL CR.		

Appendix D. Continued.

CLEARWATER RIVER DRAINAGE								
TRIBUTARY	STRATA	COUNT KETBOD	DATE	# REDDS (POSS.)	DOWNSTREAM	UPSTREAM	MALE (mm FL)	FEMALE (mm FL)
CROOKED FORK CREEK	I	GROUND	10/10/93	0	HOPEFUL CR.	UPPERMOST SNORKEL SITE		
TOTALS				13(4)			(+1[a]+3[c])	
HOPEFUL CREEK	I	GROUND	9/13/93	0	MOUTH	UPPERMOST SNORKEL SITE		
	I	GROUND	10/10/93	0	MOUTH	UPPERMOST SNORKEL SITE		
TOTALS				0				
JOHNS CREEK	I	GROUND	9/21/93 9/22/93	0	THREE FORKS (WHERE OPEN CR. AND MOORES CR. FLOW INTO JOHNS CR.)	APPROXIMATELY 1 MILE UP FROM MOUTH OF TWIN LAKES CR.		
TOTALS				0				
TWIN LAKES CREEK	I	GROUND	9/21/93	0	MOUTH	MOUTH OF HAGEN CR.		
TOTALS				0				
HAGEN CREEK	I	GROUND	9/21/93	0	MOUTH	0.25 MILES UPSTREAM FROM MOUTH		
TOTALS				0				
RED RIVER	VI	GROUND	8/25/93 8/26/93 9/9/93 9/10/93	10	MOUTH	GOLD POINT		2 @ $\bar{X}$=675
	V	GROUND	9/4/93 9/6/93	34(9)	GOLD POINT	DAWSON CR.	9 @ $\bar{X}$=870	4 @ $\bar{X}$=760

Appendix D. Contlnued.

CLEARWATER RIVER DRAINAGE

TRIBUTARY	STRATA	COUNT METHOD	DATE	# REDDS (POSS.)	DOWNSTREAM	UPSTREAM	MALE (mm FL)	FEMALE (mm FL)
RED RIVER	IV	GROUND	9/4/93	21(9)	DAWSON CR.	LITTLE MOOSE CR. (@ OLD BRIDGE CROSSING)	2 @ X̄=970	11 @ X̄=830
	VI	GROUND	9/11/93 9/13/93 10/2 J93	4	MOUTH	GOLD POINT		
	V	GROUND	9 /13/93	0	GOLD POINT	FOREST SERVICE RD. 1800		
	VI	GROUND	10/3/93 10/4/93	0	MOUTH	GOLD POINT		
	V	GROUND	10/2/93	0	GOLD POINT	FOREST SERVICE RD. 1800		
TOTALS				69(18)			11@890	17@790 (+1')

TRIBUTARY	STRATA	COUNT METHOD	DATE	# REDDS (POSS.)	DOWNSTREAM	UPSTREAM	MALE (mm FL)	FEMALE (mm FL)
WHITE CAP CREEK	III	GROUND	9/10 J93	3	MOUTH	GEORGE CR.		
	II	GROUND	9/9/93	3	GEORGE CR.	MIGR. BARRIER		700 870
TOTALS				6				2@785

TRIBUTARY	STRATA	COUNT METHOD	DATE	# REDDS (POSS.)	DOWNSTREAM	UPSTREAM	MALE (mm FL)	FEMALE (mm FL)
WHITE SAND CREEK	I	GROUND	8/31/93 9/1/93	0	MOUTH OF BIG FLAT CR.	GARNET CR. CONFLUENCE		
	I	GROUND	10/6/93 10/7 J93	2	MOUTH OF BIG FLAT CR.	MOUTH OF PACK BOX CR.		
TOTALS				2				

'Additional male salmon either not measured or only hypural length taken.
"Additional female salmon either not measured or only hypural or etandard length taken.
'Additional ealmon of unknown sex not measured.

Appendix D. continued.

CLEARWATER RIVER DRAINAGE								
TRIBUTARY	STRATA	COUNT METHOD	DATE	# REDDS (POSS.)	DOWNSTREAM	UPSTREAM	MALE (mm FL)	FEMALE (mm FL)
RED RIVER	IV	GROUND	9/4/93	21(9)	DAWSON CR.	LITTLE MOOSE CR. (@ OLD BRIDGE CROSSING)	2 @ $\bar{X}$=970	11 @ $\bar{X}$=830
	VI	GROUND	9/11/93 9/13/93 10/2/93	4	MOUTH	GOLD POINT		
	V	GROUND	9/13/93	0	GOLD POINT	FOREST SERVICE RD. 1800		
	VI	GROUND	10/3/93 10/4/93	0	MOUTH	GOLD POINT		
	V	GROUND	10/2/93	0	GOLD POINT	FOREST SERVICE RD. 1800		
TOTALS				69(18)			11@890	17@790 (+1[c])

WHITE CAP CREEK	III	GROUND	9/10/93	3	MOUTH	GEORGE CR.		
	II	GROUND	9/9/93	3	GEORGE CR.	NIGR. BARRIER		700 870
TOTALS				6				2@785

WHITE SAND CREEK	I	GROUND	8/31/93 9/1/93	0	MOUTH OF BIG FLAT CR.	GARNET CR. CONFLUENCE		
	I	GROUND	10/6/93 10/7/93	2	MOUTH OF BIG FLAT CR.	MOUTH OF PACK BOX CR.		
TOTALS				2				

[a]Additional male salmon either not measured or only hypural length taken.
[b]Additional female salmon either not measured or only hypural or standard length taken.
[c]Additional salmon of unknown sex not measured.

Appendix E. Abbreviated stream names used in Figures 3, 4, and 17.

AR	- American River
BFL	- Big Flat Creek
BFK	- Brushy Fork Creek
CFC	- Crooked Fork Creek
RR	- Red River
SFRR	- South Fork Red River
WCC	- White Cap Creek
W S S	- White Sand Creek
NFSR	- North Fork Salmon River
SFSR	- South Fork Salmon River
CURT	- Curtis Creek
JCR	- Johnson Creek
WCR	- Whiskey Creek
SAND	- Sand Creek
PAHS	- Pahsimeroi River
PATT	- Patterson Creek
MARSH	- Marsh Creek
KNAP	- Knapp Creek
SULP	- Sulphur Creek
USR	- Upper Salmon River
ALC	- Alturus Lake Creek
BRUSHY FK	- Brushy Fork Creek
CROOKED FK	- Crooked Fork Creek

Appendix F. Salmon Region portion of Idaho Supplementation Studies, Tom Curet, Regional Anadromous Fisheries Biologist, Idaho Department of Fish and Game, Salmon, Idaho.

INTRODUCTION

In 1993 a portion of Idaho Supplementation Studies (ISS) responsibilities were transferred to the Salmon Region under the direction of the newly created regional anadromous fishery biologist position. Within the region, the biologist conducted field activities on two supplementation streams, the Lemhi and North Fork Salmon rivers. This report summarizes the findings of the 1993 field efforts within these drainages.

STUDY AREA

Although ISS represents a state-wide research effort, the two drainages of focus in this report are the Lemhi and North Fork Salmon rivers. Under ISS experimental guidelines the Lemhi River is classified as a treatment stream and the North Fork as a control stream (Leitzinger et al. 1993).

The Lemhi River, a spring-fed stream in east-central Idaho, flows 90 km from its source to the Salmon River at river kilometer 417 near the city of Salmon, Idaho. The drainage is bordered by the Lemhi and Bitterroot mountain ranges (Keifer et al. 1992). Within the Salmon River drainage, the Lemhi River is an exception to the sterile streams generally encountered in the basin. The Lemhi is very productive, a result of the system being largely spring fed coupled with intensive land use activities within the drainage such as grazing.

The North Fork of the Salmon River originates along the Continental Divide in the Beaverhead Mountains on the Idaho-Montana border. The stream flows in a southerly direction for approximately 37 km through a narrow mountainous valley and enters the main Salmon River at river kilometer 368 near the town of North Fork. Throughout the entire river corridor the river exhibits little meander which results in a rather steep gradient with poor pool structure (Gebhards 1958). The principal land use activities within the drainage are mining, timber harvest, and grazing.

METHODS

<u>Parr Abundance</u>

Lemhi River

The high productivity of the Lemhi system typically has not allowed for conventional snorkeling techniques to be employed in two of three strata sampled in the drainage due to poor visibility. In 1994, in an effort to keep the sampling effort consistent across all three strata in the two main river strata, electrofishing is used to determine summer parr density

Appendix F. Continued.

estimates and standardized snorkeling techniques in the remaining stratum. For detailed information on stream stratification and study site selection protocol refer to Leitzinger et al. 1993. Table 1 lists the three strata, their location, the number of sample sites per strata and the number of sites sampled in 1993. During the 1993 field season, six sample sites in the Lemhi River were not surveyed due to either landowner rejections or poor water conditions. Transects that were sampled using snorkeling techniques followed Idaho's standardized snorkeling techniques (Appendix G 1). Sites sampled using electrofishing techniques were surveyed using a boat mounted Honda EG 5000X generator and Smith-Root VVP-15.

North Fork Salmon River

Thirty-nine of 40 sample sites in the North Fork drainage were sampled in the 1993 field season with the assistance of the Eagle Research crew. For detailed information on stream stratification and study site selection protocol refer to Leitzinger et al. 1993 Table 1 lists the three North Fork strata, their location and the number of sample sites per strata. Transects were sampled using Idaho's standardized snorkeling techniques (Table Fl 1.

Physical Habitat

Physical habitat surveys were recorded on one to two transects per stratum. Vertical drop, percent gradient (vertical drop/total transect length X 100). depth, substrate composition and conductivity were measured. Vertical drop was measured, with a hand-held surveyors transit and a stadia rod, as the elevation drop between the upper and lower transect boundaries. Depth and substrate composition were determined at 1/4, l/2, and 3/4 points across each width measurement. Surface substrate composition was estimated using a view box (30 cm x 30 cm) to approximate the percent of sand/silt (< 33 mm), gravel (4-64 mm), rubble (65-256 mm), boulder (257-256 mm), and bedrock (>2,049 mm) (Leitzinger et al. 1993).

PIT Tagging

Juvenile chinook salmon were PIT tagged following the completion of snorkeling on the North Fork and during electrofishing transect surveys on the Lemhi River. Juvenile chinook were collected on the North Fork using both electrofishing and seining techniques.

Fish were collected for PIT tagging when stream temperatures were less than 20°C. Juveniles less than 55 mm (fork length) were not tagged. No more than 20 juveniles were anesthetized (MS 222) at one time, and tagging equipment was sterilized in a 70% ethanol solution to reduce the risk of disease transmission. Juveniles were detained for l-24 hours to observe delayed mortality and possible tag loss. Released fish were dispersed throughout the capture transect.

Baited minnow traps were also used to collect juvenile chinook, however their success was very limited.

Appendix F. Continued

Table Fl . Chinook salmon and steelhead parr population estimates and densities for the North Fork Salmon and Lemhi rivers, 1993.

Salmon River drain tributary	Strata (from-to)	Number sections	Chinook population estimate	90% C.I.	Number/ 100 m^2	Steelhead age I population estimates	90% C.I.	Steelhead age II population estimates	90% C.I.
North Fork Salmon River	3 (mouth to Hughes Creek	8 (9)*	852	670	.816	1,960	672	1,008	592
	2 (Hughes Creek to Johnson GUI)	17	2,688	1,912	1.97	4,027	753	1,322	347
	1 (Johnson GUI to Headwaters)	14	0	0	0	739	458	416	367
Total	All Strata	40	3,540	1,969	1.27	6,727	1,064	2,746	739
Lemhi River	3 (Big Springs Cr)	12	0	0	0	1,378	1,066	822	558
	2 (Hayden Creek weir to Cottom Lane)	7 (10)*	891	496	.386	0	0	445	377
	1 (Cottom Lane to Leadore)	7 (10)*	1,681	1,373	,666	685	441	2276	686
Total	All Strata	26	2,571	1,343	,439	2,063	1,089	3,543	894

Spawning Escapement

Redd Counts

Chinook redd counts were conducted on the Lemhi River three times in 1993; two ground counts and one aerial survey. Redds were inventoried in the main river from the Hayden Creek weir to the town of Leadore.

Ground counts for chinook redds were conducted on the North Fork three times in 1993. Counts were conducted from 1/4 mile upstream from the mouth of the North Fork to the mouth of Twin Creeks.

All carcasses encountered were measured (fork length), sexed, and aged (estimate of years in ocean). Where possible, unspent eggs were counted to ascertain percent spawned and scales were taken. Estimates of age and sex were recorded for live adults on redds. Redds were flagged to avoid duplicate counts and all redds were marked on USGS 7.5 min series topographical maps.

RESULTS AND DISCUSSION

Parr Abundance and PIT Tagging

Juvenile chinook salmon population estimates for the Lemhi and North Fork Salmon Rivers were 2,571 and 3,540, respectively (Figure F1). Chinook salmon densities for the Lemhi were .439 fish/l00 m^2 and 1.27 fish/100/m^2 in the North Fork Salmon River (Table FI). Confidence intervals for ISS study designs should be within 30% of the chinook salmon estimate, however in neither drainage was this realized. Lack of sample size and low seeding levels probably account for this occurrence. During the 1994 field season, in an effort to obtain acceptable confidence intervals, we will increase the number of sample sites in the North Fork and initiate a mark recapture effort in the Lemhi where electrofishing estimates have been unreliable.

Twelve chinook were marked during PIT tagging efforts on the Lemhi River. In the North Fork Salmon River 318 chinook were tagged in 1993 (Table 2). No direct or delayed tagging mortality occurred in the Lemhi River and mortality was 0.006% in the North Fork Salmon River. Because of low seeding levels in the Lemhi in 1993, it was very difficult to capture fish for tagging, however 1994 tagging efforts should be more successful.

Pl vsical Habitat

The physical habitat data is being summarized and put into a database.

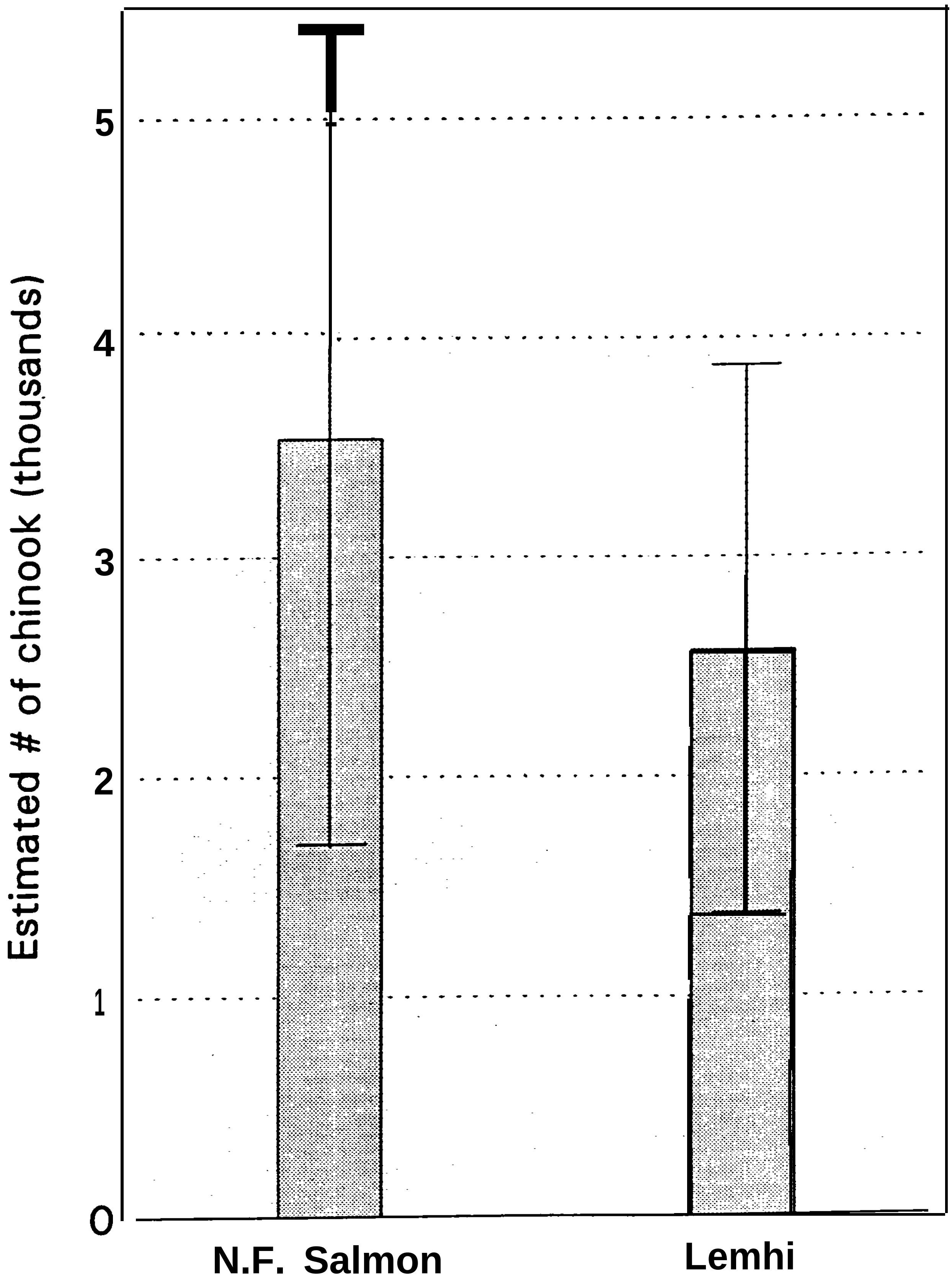

Figure F1. Juvenile chinook salmon population estimates for the Lemhi and North Fork Salmon rivers.

Appendix F. Continued.

Table F2. ISS summer parr tagging summary, Salmon Region 1993.

Tributary	Number tagged	Number of mortalities (%)	Number of lost tags (%)	Number of fish released
North Fork Salmon River	318	2/(.006)	0(0)	318
Lemhi River	12	0(0)	0(0)	12

Spawning Escapement

Total redd counts between the Lemhi and North Fork Salmon rivers were 37 and 17, respectively. In both drainages redd counts were conducted between late August and early September. In the North Fork, the number of redds increased between 1991 and 1993 (Figure F2). The first year, 1993, a complete ground count was conducted as part of Idaho Supplementation Studies, although aerial redd counts have been conducted annually for several decades. Using 1991's aerial redd counts as a baseline the number of redds counted in the Lemhi drainage also declined between 1991 and 1992 and rebounded slightly between 1992 and 1993 (Figure F2).

CONCLUSIONS

The main focus of efforts in 1994 will be to reduce confidence intervals for chinook estimates within acceptable levels. The 1993 season progressed quite smoothly considering the work load and logistics of equipment and personnel sharing.

Appendix F. Continued.

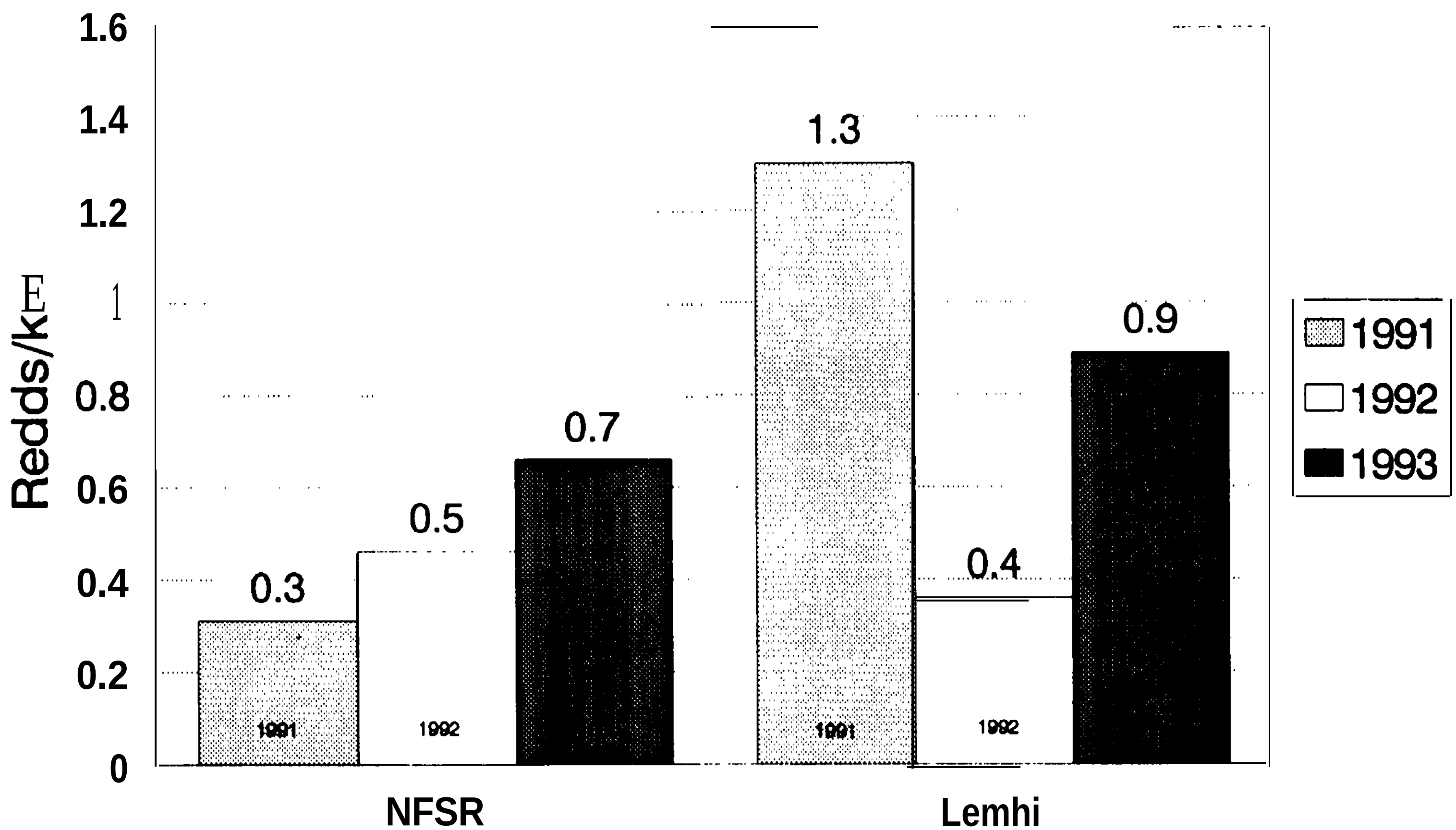

Figure F2. 1993 chinook redd counts in Salmon Region ISS study streams.

Appendix F. Continued.

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Appendix G. Summer parr abundance and PIT tagging in Johnson Creek, 1993. Submitted by Kimberly A. Apperson, Regional Fishery Biologist, Idaho Department of Fish and Game, McCall, Idaho.

RESULTS

Summer Parr Abundance

In 1993, crews estimated juvenile chinook salmon abundance at 33 sites in Johnson Creek. A population estimate for the entire stream was calculated by summing population estimates for individual blocks or strata. Sampled sites were stratified three different ways: by channel type, by habitat type (pool, run, riffle, and pocketwater), and by proximity to 1992 redd locations (Table GI). One site was snorkeled in each Rock Creek and Sand Creek, tributaries to Johnson Creek, but because no other tributaries were represented, these sites were omitted from the population estimates. No parr were observed in the tributaries.

The streamwide population estimate calculated by habitat type was double the estimates produced by stratifying samples by stream reach or by proximity to the previous year's redds. Relative 90% confidence intervals did not change much among the three estimates, being approximately half of the estimate. The lowest bound was produced by stratifying samples by proximity to 1992 redds (22,420 parr + 9,616). Confidence intervals of 90% were calculated by multiplying the standard deviation by 1.65.

I found many inconsistencies with stream lengths provided in the anadromous species presence/absence database (Northwest Power Planning Council files, 1991) and therefore measured the majority of stream lengths by tracing 7.5 minute topography maps with a map wheel (Table G2). Total stream length was similar. I used my stream length measurements in population estimate calculations.

Stream areas snorkeled and total stream areas in Table GI are inconsistent because different sites or partial sites grouped together in different stratifications resulted in different average widths used to calculate areas.

PIT Tag&g

We used minnow traps to capture 70 parr from August 10 through 12. Only 43 of the parr were >60 mm and were tagged. Because of very low numbers of parr observed while placing traps, and because a third of the parr were too small to tag, we aborted further tagging effort. We had one trapping mortality.

Appendix G. Continued.

Table Gl . Population estimates by three stratification strateaies of summer chinook salmon Parr in Johnson Creek, 1993.

Stratification type	Stratum	Number of sites	Area snorkeled (m^2)	Total area (m^2)	Population estimate	Standard deviation of the estimate	90% CI
Stream reach and channel type	I: Headwaters to old Burnt log Trail crossing	17	10,636	217,370	12,161	5,055	8,341
	II: Burnt Log Trail crossing to Whitehorse Rapids	4	2,465	177,795	911	905	1,493
	III Whitehorse Rapids to Deadhorse Rapids	9	11,942	302,843	2,736	1,675	2,764
	IV: Deadhorse Rapids to mouth	3	4,103	160,755	4,876	3,686	6,082
Total		33	29,147	858,762	20,684	6,540	10,791
Habitat type	Pocketwater	11	10,216	149,479	2,080	1,216	2,006
	Pool	13	7,080	162,154	11,935	5,758	9,501
	Riffle	10	3,129	120,777	2,788	1,449	2,390
	Run	22	7,564	328,529	31,097	14,094	23,255
Total		55 .	27,989	760,939	47,901	15,342	25,314
Proximity to 1992 redds	I: Headwaters to Sand Creek (0 redds)	[illegible]	3,482	90,405	42	41	68
	II: Sand Creek to old Burnt log Trail Crossing (7 redds)	[illegible]	7,837	123,928	13,162	4,484	7,399
	III: Burnt Log Trail Crossing to Wapiti Bridge (0 redds)	[illegible]	8,115	377,933	52	52	85
	IV: Wapiti Bridge to mouth	6	9,714	32 1,404	9,163	3,722	6,141
Total		33	29,148	913,670	22,420	5,828	9,616

[a] Multiple habitat type per snorkeled site resulted in a larger sample size for this stratification than for other two stratification methods

Appendix G. Continued.

Table G2. Comparison of reach lengths for Johnson Creek between presence/absence database and map wheel measurements from topography maps.

Stream reach	Length from presence/ absence database (meters)	Length from map wheel measurements (meters)
Headwaters to Boulder Creek	6,597	6,597[b]
Boulder Creek to Whiskey Creek	1,609	3,218
Whiskey Creek to Sand Creek	3,540	4,023
Sand Creek to Rock Creek	3,862	2,092
Rock Creek to Landmark Creek	1,609	2,896
Landmark Creek to old Burnt Log Trail Crossing		5,471
old Burnt Log Trail Crossing to Halfway Creek	16,895	11,585
Halfway Creek to Burnt Log Creek	3,218	3,540
Burnt Log Creek to Trapper Creek	4,988	3,540
Trapper Creek to Wapiti Bridge		2,639
Wapiti Bridge to Deadhorse Rapids	10,619	5,310
Deadhorse Rapids to Riordan Creek		1,931
Riordan Creek to mouth	7,360	7,241
TOTAL	60,297	60,083
Rock Creek: headwaters to mouth	7,241	
Sand Creek: headwaters to mouth	10,459	

[b] Not measured

Appendix G. Continued.

DISCUSSION

Stream conditions were drastically different between snorkel sampling conducted in 1992 and 1993. During August 1992, snorkeling discharge in Johnson Creek at Yellow Pine was 1.68 to 1.83 m^3 (56 to 61 cfs) and water temperatures ranged from 13°C to 23°C. In 1993 we conducted the majority of snorkeling from July 10 through 16 when discharge ranged from 10.02 to 11.73 m^3 (334 to 391 cfs) and water temperatures were 9°C to 14°C. High turbulence impaired visibility in higher gradient sites. Turbulence was not uniform throughout a given site and it was therefore impossible to quantify actual snorkeling visibility. We were unable to snorkel the three lowest sites until August 10 because of high water. Even in August 1993 discharge was almost three-fold higher (4.44 m^3) than during snorkeling the previous year. Water temperature was 15°C on August 10, 1993.

Caution should be taken when comparing population estimates between years, and physical stream conditions should be incorporated as covariates.

Appendix H. Summary of chinook salmon parr abundance in Red River, American River and White Cap Creek, 1993. Submitted by Jody K. Brostrom, Regional Anadromous Fisheries Biologist, Idaho Department of Fish and Game, Lewiston, Idaho.

INTRODUCTION

In 1993, the Idaho Department of Fish and Game (IDFG) divided the workload for implementation and evaluation for Idaho Supplementation Studies (ISS) between the Fisheries Research section in Nampa, and the regional offices in Lewiston, McCall, and Salmon. In 1993, the majority of ISS tasks in the Clearwater River drainage were completed by the crew in Nampa. The exception was the summer parr abundance estimates in Red River (treatment-fall presmolt), American River (treatment-smolts) and White Cap Creek (control), which this report covers. Outmigrant trapping activities in 1993 are covered elsewhere in this document. Johns Creek (control) was not sampled as it was deemed a lower priority since only one redd was seen in 1992. Clearwater Region personnel will be responsible for all tasks in Red River, American River, Ten Mile Creek/Johns Creek, and White Cap Creek beginning in 1994.

METHODS

Parr Abundance

Supplementation sites were sampled using standardized established methods (Bowles and Leitzinger, 1991). The number of sites sampled in all streams was expanded to obtain data in representative habitat types and in strata not previously sampled. The total number of sites surveyed included 42 sites (28 new sites) in Red River, 34 sites (0 new sites) in American River, and 17 sites (8 new sites) in White Cap Creek. Photos were taken of all sites. Sampling occurred between July 7 through August 12, 1993.

PIT Tagging of summer Parr

An attempt was made to capture chinook parr in Red River during July and August for PIT tagging. Baited minnow traps and a beach seine were used. All chinook captured were smaller than 55 mm fork length, which is the minimum size to tag recommended by the PIT tag Steering Committee (1992) and Kiefer and Forster (199 1). Fifty chinook parr were collected for genetic analysis in conjunction with University of Idaho personnel for a study within the ISS Experimental Design (Bowles and Leitzinger 1991).

Appendix H. Continued

RESULTS

Parr Abundance

A total of 93 ISS sites were snorkeled by regional personnel from Lewiston, occasionally assisted by personnel from Nampa. Population size of chinook salmon parr was estimated three ways: by stratifying sample sites by reach (gradient and channel type), by reach blocked on habitat type (pool, riffle, run, and pocketwater), and by habitat type (Table HI). The population estimates ranged from 1,599 to 1,707 for American River; 6.41 1 to 11,348 for Red River; and 1,747 to 6,130 for White Cap Creek. Confidence limits were between 13.4% and 38.8% of the population estimate (Table H2).

DISCUSSION

None of the different stratifications used to estimate parr populations gave consistently tighter estimates than another (Table H2). The difference in coefficients of variation between methods was lowest for American River (2.6). followed by Red River (7.2) and White Cap Creek (14.2). White Cap Creek, in the Selway-Bitterroot Wilderness, is the least accessible, and only 14 transects were snorkeled. However, the coefficients of variation were similar to those of American River, where 34 transects were sampled. We will increase the number of transects snorkeled in 1994, and sample habitat proportionately to what is present, to try to tighten our estimates.

Water conditions were different in 1993 than in the previous two years (Leitzinger, personal communication). Flow was higher for a longer duration, and temperatures averaged between 12°C and 14°C, much cooler than in other years. Due to lower water temperatures, chinook parr were smaller and used slackwater shoreline areas almost exclusively in American River and Red River. We observed, but did not enumerate, chinook parr in side channels and backwater slough areas, which likely affected parr estimates.

I calculated the number of summer parr that could potentially be produced by multiplying the number of redds counted in 1992 by the average number of eggs per female chinook at the Red River satellite facility, and then multiplying by three different egg to parr survival rates reported by Kiefer and Lockhart (1995) (Table H3). Our snorkel estimates were lower than the calculations for both American and Red rivers, but was within range for White Cap Creek. Given the low number of redds observed in White Cap Creek, and the difficulty in sampling all reaches in the drainage, estimating the number of parr by this method may be a viable option to more intensive snorkeling.

The estimated number of chinook presmolts emigrating from Red River in the fall of 1993 was 6,309, only 102 less than the population estimate calculated from stratifying by habitat. Trapping conducted in 1992 indicated that 35% of BY91 parr emigrated in fall. Because this report covers only summer parr and fall trapping estimates, we have an incomplete picture on the status of BY92 chinook. Reporting data by brood year rather than field season or fiscal year would allow a more thorough evaluation of how well our methods are tracking chinook production.

Appendix H. Continued.

Table HI. Population estimates by three stratification strategies of spring chinook parr in American and Red rivers, and in White Cap Creek, 1993.

Stratification type	Stratum		Number of sites sampled	Total area sampled	Total area in stratum	Percent of total area sampled	Population estimate	90% CI	Number/ 100 m^2
American River	I: Headwaters (corrals and above)		9	1,82 1	40,474	4.5	227	232	0.56
By reach and channel type	II: Corrals to Box Sing Cr		13	3,808	125,503	3.0	1,285	853	1.02
	III: Box Sing Cr to mouth		12	4,416	91,588	4.8	87	109	0.10
	Total		34	10,045	257,565	3.9	1,599	851	1.56
Habitat type	Run		38	5,450	163,467	3.3	836	593	0.51
	Pool		20	2,648	44,343	5.9	719	554	1.62
	Riffle		22	1,526	40,162	3.6	134	143	0.33
	Pocketwater		0	0	3,018	0.0	0	0	0.00
	Total		80	9,624	250,995	3.7	1,689	805	0.62
Stream reach blocked on habitat type	Run	Reach I	12	1,094	21,296	5.1	66	97	0.32
		Reach II	13	1,249	77,944	1.6	875	758	1.12
		Reach III	13	3,107	60,126	5.2	53	66	0.09
	Pool	Reach I	5	416	8,874	4.7	352	491	3.89
		Reach II	12	1,754	25,595	6.9	276	235	1.08
		Reach III	3	478	10,072	4.7	0	0	0.00
	Riffle	Reach I	6	259	9,109	2.8	0	0	0.00
		Reach II	13	799	15,I 18	5.3	85	91	0.56
		Reach III	3	468	18,332	2.6	0	0	0.00
	Pocketwater	Reach I	0	0	1,492	0.0	0	0	0.00
		Reach II	0	0	752	0.0	0	0	0.00
		Reach III	0	0	703	0.0	0	0	0.00
	Total		80	9,624	249,413	3.9	1,707	868	0.59

Appendix H. Continued.

Table Hl . Continued.

Stratification type	Stratum		Number of sites sampled	Total area sampled	Total area in stratum	Percent of total area sampled	Population estimate	90% CI	Number/ 100 m^2
Red River By reach and channel type	I: Headwaters to Red River CG		7	2,472	41,770	5.9	25	46	0.06
	II: Red River CG to weir		9	4,969	83,141	6.0	57	68	0.07
	III: Weir to Little Moose Cr Rd		7	4,835	34,524	14.0	1,055	649	3.06
	IV: Little Moose Cr Rd to Dawson Cr		7	7,399	53,188	13.9	4,265	1,793	8.02
	V: Dawson Cr to Gold Point		8	8,740	96,135	9.1	650	756	0.67
	VI: Gold Point to mouth		6	3,493	174,095	2.0	5,296	2,202	3.04
	Total		44	31,908	482,853	6.6	11,348	2,567	2.49
Habitat type	Run		49	23,683	294,973	8.0	4,082	1,549	1.38
	Pool		13	1,766	74,297	2.4	548	400	0.74
	Riffle		20	3,429	65,768	5.2	1,781	1,583	2.71
	Pocketwater		0	0	14,712	0.0	0	0	0.00
	Total		82	28,878	449,750	6.4	6,411	**2,197**	1.21
Stream reach blocked on habitat type	Run	Reach I	7	1,282	18,167	7.1	0	0	0.00
		Reach II	13	2,515	42,806	5.9	159	233	0.37
		Reach III	6	3,038	29,983	10.1	533	545	1.78
		Reach IV	8	6,444	36,462	17.7	1,150	625	3.18
		Reach V	8	7,954	69,123	11.5	466	531	0.68
		Reach VI	7	1,540	117,994	1.3	3.284	2,653	2.79
	Pool	Reach I	3	172	11,563	1.5	0	0	0.00
		Reach II	4	340	19,290	1.8	0	0	0.00
		Reach III	1	224	1,926	11.6	113	0	1.34
		Reach IV	4	689	11,128	6.2	2,065	1,312	18.20
		Reach V	1	341	12,759	2.7	0	0	0.00
		Reach VI	0	0	24,589	0.0	0	0	0.00

Appendix H. Continued.

Table HI. Continued.

Stratification type	Stratum		Number of sites sampled	Total area sampled	Total area in stratum	Percent of total area sampled	Population estimate	90% CI	Number/ 100 m^2
	Riffle	Reach I	3	535	15,590	3.4	0	0	0.00
		Reach II	9	1,955	17,797	10.9	0	0	0.00
		Reach III	4	1,340	6,163	21.7	187	173	3.10
		Reach IV	2	279	1,958	14.2	418	155	20.89
		Reach V	2	479	12,693	3.8	0	0	0.00
		Reach VI	0	0	14,451	0.0	0	0	0.00
	Pocketwater	Reach I	0	0	0	0.0	0	0	0.00
		Reach II	0	0	1,663	0.0	0	0	0.00
		Reach III	0	0	276	0.0	0	0	0.00
		Reach IV	0	0	2,606	0.0	0	0	0.00
		Reach V	0	0	769	0.0	0	0	0.00
	Reach VI		0	0	14,451	0.0	0	0	0.00
	Total		82	29,127	481,207	6.1	8,375	2,616	2.18
White Cap Creek By reach and channel type	II: Elk Creek to Canyon Creek		7	3,204	92,968	3.4	1,834	2,087	1.97
	III: Canyon Creek to mouth		7	5,771	214,392	2.7	4,296	2,705	2.00
	Total		14	**8.975**	307,360	2.9	6,130	3,133	1.99
Habitat type	Run		12	7,994	145,334	5.5	1,686	1,212	1.16
	Pool		0	0	32,055	0.0	0	0	0.00
	Riffle		0	0	88,193	0.0	0	0	0.00
	Pocketwater		2	981	36,451	2.7	61	382	0.17
	Total		14	**8,975**	302,033	3.0	1,747	1,208	0.33

Appendix H. Continued.

Table H1. Continued.

Stratification type	Stratum		Number of sites sampled	Total area sampled	Total area in stratum	Percent of total area sampled	Population estimate	90% CI	Number/ 100 m^2
Stream reach blocked on habitat type	Run	Reach II	6	2,818	33,309	8.5	767	723	2.30
		Reach III	6	5,177	119,778	4.3	2,733	1,543	2.28
	Pool	Reach II	0	0	16,363	0.0	0	0	0.00
		Reach III	0	0	14,151	0.0	0	0	0.00
	Riffle	Reach II	0	0	28,171	0.0	0	0	0.00
		Reach III	0	0	59,817	0.0	0	0	0.00
	Pocketwater	Reach II	1	387	15,964	2.4	0	0	0.34
		Reach III	1	595	20,610	2.9	69	0	0.00
	Total		14	8,977	308,163	2.9	3,569	1,562	0.62

Appendix H. Continued.

Table H2. Summary of population estimates of spring chinook parr in American River, Red River, and White Cap Creek, 1993.

Stratification type	Degrees of freedom	Population estimate	Population standard deviation	Coefficient of variation
American River				
Stream reach and channel type	31	1,599	501	31.3%
Habitat type	77	1,689	484	28.7%
Stream reach blocked on habitat type	71	1,707	521	30.5%
Red River				
Stream reach and channel type	38	11,348	1,523	13.4%
Habitat type	79	6,411	1,320	20.6%
Stream reach blocked on habitat type	66	8,375	1,568	18.7%
White Cap Creek				
Stream reach and channel type	12	6,130	1,758	28.7%
Habitat type	12	1,747	678	38.8%
Stream reach blocked on habitat type	12	3,569	877	24.6%

Appendix H. Continued.

Table H3. Estimated parr production from brood year 1992 based on the number of eggs per female and three survival rates, American River, Red River, and White Cap Creek, 1993.

Stream	Number of redds	Number of eggs per female	Parr abundance estimates egg to parr survival 13.9%	11.9%	27.0%	Reach and channel type	Habitat	Reach blocked on habitat type
American River	5	3,810[a]	2,648	2,267	5,144	1,599	1,689	1,707
Red River	44	3,810	23,302	19,949	45,263	11,348	6,411	8,375
White Cap Creek	2	4,070[b]	1,131	969	2,148	1,758	678	877

[a] From female chinook collected at Red River Satellite Facility

[b] From female chinook collected at Crooked Fork Satellite Facility

Appendix H. Continued.

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Appendix I. Ecological Effects of Hatchery Reared Chinook Salmon on Naturally Produced Chinook salmon.

1993 Annual Report

ECOLOGICAL EFFECTS OF HATCHERY REARED CHINOOK SALMON Oh' NATURALLY PRODUCED CHINOOK SALMON - 1993

by

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Idaho Supplementation Studies
Small-scale Studies
Idaho Department of Fish and Game

and

Bonneville Power Administration
Portland, Oregon

May 1994

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Abstract

Ninteen-ninety-three was the second of three years for small-scale studies associated with the Idaho Supplementation Studies (ISS) project. Our goal for the ISS small-scale studies was to evaluate some of the risks and benefits of using supplementation strategies to enhance natural production of chinook salmon stocks in Idaho rivers and streams. We investigated the interactions possible between hatchery and natural chinook salmon at different densities and sizes through experimental trials run in an artificial stream.

There were significant differences in habitat selection by allopatric natural and hatchery chinook salmon, and the naturally reared chinook salmon parr showed significant habitat selection shifts when in the presence of hatchery chinook salmon. Specifically, use of preferred habitats by natural fish decreased proportionally to increased use of those habitats by hatchery fish. Differences appear to be caused by habitat displacement by the more aggressive hatchery fish. There were no differences in emigration, and few significant differences in growth of natural fish when combined with hatchery fish.

There were no differences in emigration, aggression, and growth, and only slight shifts in habitat selection when hatchery chinook salmon par-r were present with brook trout predators. Predation occurred only with the smaller (less than 80 mm) chinook salmon parr

Chinook salmon parr released in Squaw and Pete King Creeks at a single release site dispersed through the creeks, but were concentrated near the release sites until September, when water temperatures dropped below 7°C. Chinook salmon parr released at multiple sites into White Sands Creek. via helicopter drops, appeared to have dispersed quickly from the stocking area soon after release.

Introduction

The use of hatchery produced fish to supplement natural anadromous salmonid stocks in the Columbia River Basin has increased over the last few decades in an attempt to reverse the decline of natural stocks. The continued reduction of natural salmonid stocks despite the release of millions of hatchery smolts annually has raised questions as to the effectiveness of current hatchery production and stocking techniques. The success of any supplementation project depends on several factors; the condition and character (behavior) of the hatchery fish at the time of release. the stocking technique used, the condition of the receiving waters. and the interactions with resident fish populations. Of special concern is the effect hatchery fish will have on the naturally produced salmonid stocks following release. It has become a high priority within Idaho and the Columbia River Basin to assess the benefits and risks associated with using hatchery fish to enhance naturally reproducing salmon and steelhead stocks. These efforts are necessary to determine the relative utility of supplementation as a recovery tool for anadromous stocks.

The goal of the Idaho Supplementation Studies (ISS) is to “assess the use of hatchery chinook salmon to restore or augment natural populations, and to evaluate the effects of supplementation on the survival and fitness of existing natural populations” (Bowles and Leitzinger 1991), towards this goal. the Idaho Supplementation Studies incorporates three levels of investigation. The first two levels are the large-scale population productivity studies and the evaluation of specific supplementation strategies in study streams throughout the state over several chinook salmon generations (12-15 years). The third level of investigation is the small-scale studies to investigate specific questions regarding the techniques and effects of supplementation on hatchery and naturally produced chinook salmon productivity and on the potential interactions between hatchery and natural fish in Idaho streams. In this report we summarize the second field season (1993) of small-scale studies conducted by personnel of the

Idaho Cooperative Fish and Wildlife Research Unit (ICFWRLJ). We-also summarize results from ICFWRU's component of the large-scale studies associated with the ISS.

During 1993, we investigated the interactions that occur between hatchery and naturally produced chinook salmon in controlled experiments, as well as the effects of predation on hatchery fish, and how these interactions may influence the productivity of both groups of fish. The types of interactions possible between hatchery and natural chinook salmon include competition for space and food, and aggressive encounters (Steward and Bjomn 1990). These interactions can potentially lead to modifications in the migration behavior, growth and survival rates, reproductive success, and genetic makeup of the natural stocks. The main questions addressed during this study involved how the size and density of fish at time of stocking influenced the hatchery/natural fish interactions and productivity.

We also investigated the post-release behavior of hatchery chinook juveniles in 1993. Hatchery produced chinook salmon parr and smolts released into streams in the Clearwater and Salmon River drainages were monitored using snorkel surveys to determine the behavior and dispersion following release into a natural stream.

Our component of the ISS large-scale studies during 1993 included: monitoring the movement of adult and juvenile chinook salmon and estimating chinook salmon parr production in the Lemhi River, Idaho; investigating the survival and travel times of PIT-tagged chinook salmon juveniles from the Lemhi River to Lower Granite Dam; and the collection of chinook salmon smolts and pre-smolts from 12 Idaho streams and two hatcheries to establish a genetic database for these stocks.

Objectives

Small-scale Studies

1. Determine if hatchery-produced juvenile chinook salmon successfully disperse, survive, and grow following release into infertile Idaho streams.

2. Determine the importance of size and density of hatchery fish at time of release on the interactions between hatchery and naturally-produced chinook salmon.

3. Determine if resident trout, particularly brook trout, reduce the survival of released hatchery chinook salmon.

4. Determine relative survival benefits and travel times to Lower Granite Dam for naturally-produced chinook salmon smolts released at lower, mid, and upper Lemhi River si tes.

Large-scale Studies

5. Determine the extent and magnitude of chinook salmon juvenile downstream movement past the Lemhi River weir.

6. To PIT tag 1,800 chinook salmon juveniles at the Lemhi River weir for detection at Lower Granite Dam.

7. Determine the adult chinook salmon escapement past the Lemhi River weir.

8. Collect juvenile chinook salmon from Idaho streams and hatcheries for electrophoretic analysis to be used to establish a genetic database of these stocks.

Study Area

The experiments were conducted at the Hayden Creek Research Station (HCRS) in the Lemhi River Valley, about 53 km southeast from the town of Salmon, Idaho (Figure 1). The HCRS is three miles up Hayden Creek from the Lemhi River. The downstream movement of chinook salmon juveniles, and the upstream movement of chinook salmon adults were monitored at the Lemhi River weir, located just upstream from the mouth of Hayden Creek. Chinook salmon were also PIT tagged at the weir to determine survival rates from the Lemhi River to Lower Granite Dam (about 443 river km).

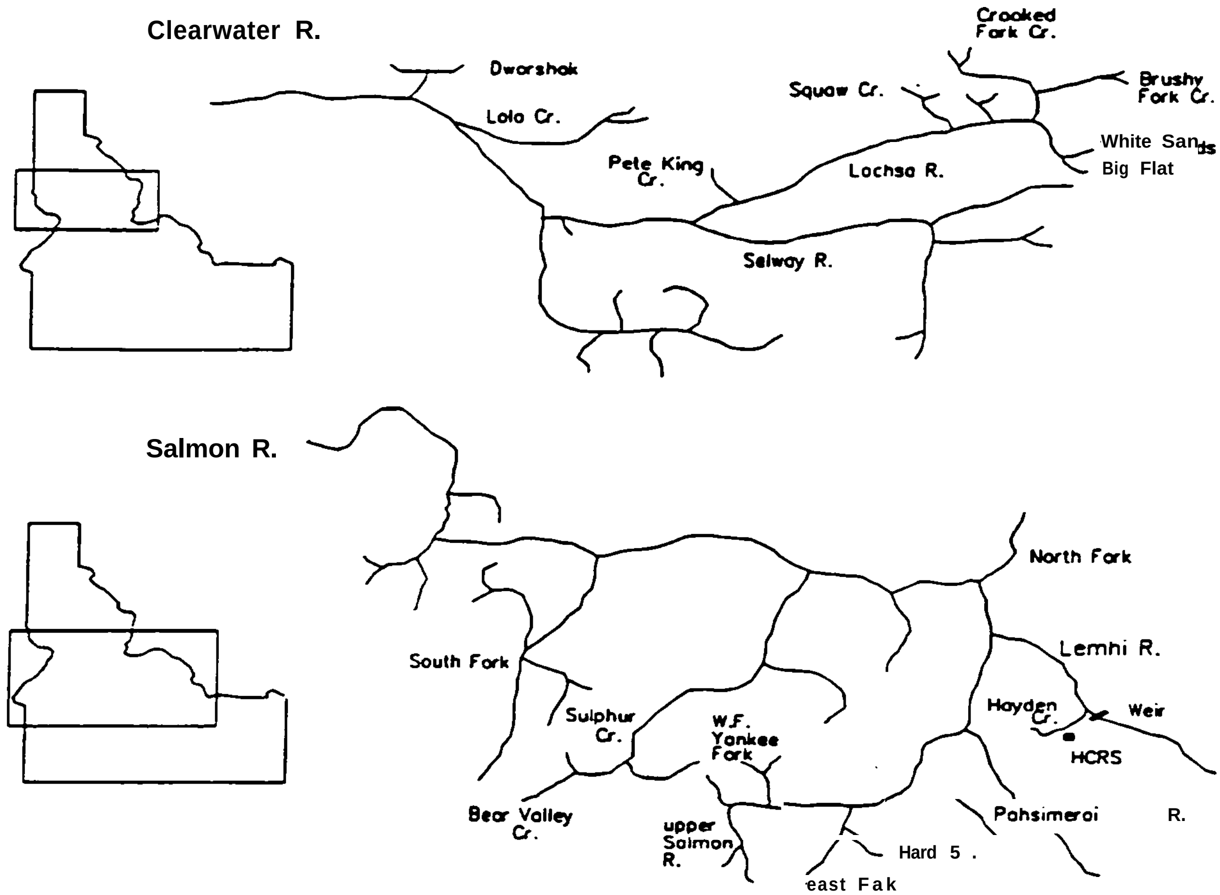

Figure 1. Study areas during 1993 field season.

Summer parr population estimates of chinook salmon in the Lemhi River upstream from the Lemhi River weir were made by personnel from the IDFG using electroshocking techniques. The results of this sampling will be discussed in the IDFG portion of this report.

The dispersion of hatchery-reared chinook salmon following their release was monitored in several streams throughout the Salmon and Clearwater rivers' drainages. Chinook salmon smolts were released into the East Fork Salmon River, South Fork Salmon River, and the upper Salmon River in the Stanley Basin. Chinook salmon parr were released in Squaw, Pete King, White Sands, and Big Flat creeks in the Lochsa River drainage (Figure 1).

We attempted to collect chinook salmon from 12 streams in the Salmon and Clearwater rivers' drainages to establish a genetic database of these naturally produced stocks. This was the third year of a three year sampling effort. The streams sampled in the Salmon River drainage were Bear Valley Creek, West Fork of the Yankee Fork, East Fork Salmon River, Herd Creek, Pahsimeroi River, Lemhi River, Sulphur Creek and the North Fork Salmon River. The streams sampled from the Clearwater River drainage were Brushy Fork Creek, Crooked Fork Creek, Red River and Lolo Creek. In addition, two hatcheries were sampled; the East Fork Salmon River Satellite Station (these fish were housed at Sawtooth Fish Hatchery) and Dworshak National Fish Hatchery.

Dispersion of Stocked chinook salmon

Dispersion of hatchery-reared chinook salmon following their release is desirable to use most of the rearing potential of the receiving stream and to reduce the impact on the endemic fish stocks. In 1993, we compared the dispersion of hatchery-reared chinook salmon smolts and parr from single and multiple release sites to determine which strategy produced the wider distribution of fish within a stream.

Prior to release of the hatchery fish, the streams to be stocked were snorkeled to determine the number of natural trout and salmon present. During and following the releases, we monitored the dispersion of the hatchery fish by snorkeling transects established upstream and downstream from the stocking sites These same transects were snorkeled periodically following releases, until the majority of the hatchery fish had left the streams. Both smolts stocked in the spring, and parr released in the summer were monitored.

Dispersion of Smolts.

Chinook salmon smolts were released at multiple sites in the East Fork Salmon River and upper Salmon River, while a single release site was used in the South Fork Salmon River. On 30 April 1993, 30,000 chinook salmon smolts from the Sawtooth Hatchery were released at two sites on the East Fork Salmon River; 8 and 13 km upstream from the East Fork weir. On the same day 52,000 chinook salmon were released at three sites on the upper Salmon River; 16, 31, and 33 km upstream from the Sawtooth Hatchery weir. On 21-22 April, 300,000 chinook salmon smolts from the McCall Hatchery were released into the South Fork Salmon River from the Knox Bridge, near Warm Lake. Transects in each of these rivers were snorkeled one to two days before, and 24 hours and one week following release of the hatchery smolts.

Results and Discussion. - No naturally produced chinook salmon juveniles were observed in the three streams prior to release of the hatchery smolts. Although there is natural production in these streams, it appeared that the natural chinook salmon had not emerged from the gravel (young-of-year) or from the winter cover (yearlings) at the time of the stockings. At the time of the releases, the streams were cold (2 to 5°C) and clear, and the main spring runoff had not yet occurred.

The released chinook salmon smolts moved downstream immediately following release in all three streams. At two of the streams, East Fork Salmon River and South Fork Salmon River, an observer was in the water during the releases. In both streams the majority of the smolts moved downstream en masse directly after release. We found very few, if any, hatchery fish in the three streams 24 hours after the stocking events and no hatchery fish were observed during snorkel surveys made one week following the releases.

Screw traps were operating on all three streams at the time of the smolt releases. On the upper Salmon River, the hatchery fish reached the screw trap (located at the Sawtooth Hatchery weir) two days after the releases, and passed the trap-over the following three day period (Russ Kiefer, IDFG, personal communication). There was not a noticeable change in the movement of natural chinook salmon smolts during this same period (Figure 2). On the East Fork Salmon River, the hatchery fish moved past the screw trap (located just downstream from the Fast Fork weir) for three days following their release (Robb Keith, Shoshone-Bannock Tribes, personal communication). In this case the number of natural smolts collected in the screw trap increased significantly from six fish per day, during the previous three day period, to 11 fish per day during the three days in which the hatchery fish were moving downstream, (Chi-Square $P < 0.05$). The bulk of the hatchery smolts released into the South Fork Salmon River moved downstream past the screw trap (about 1 km) in five days (Eric Leitzinger, IDFG, personal communication). Natural fish movement during this same five day

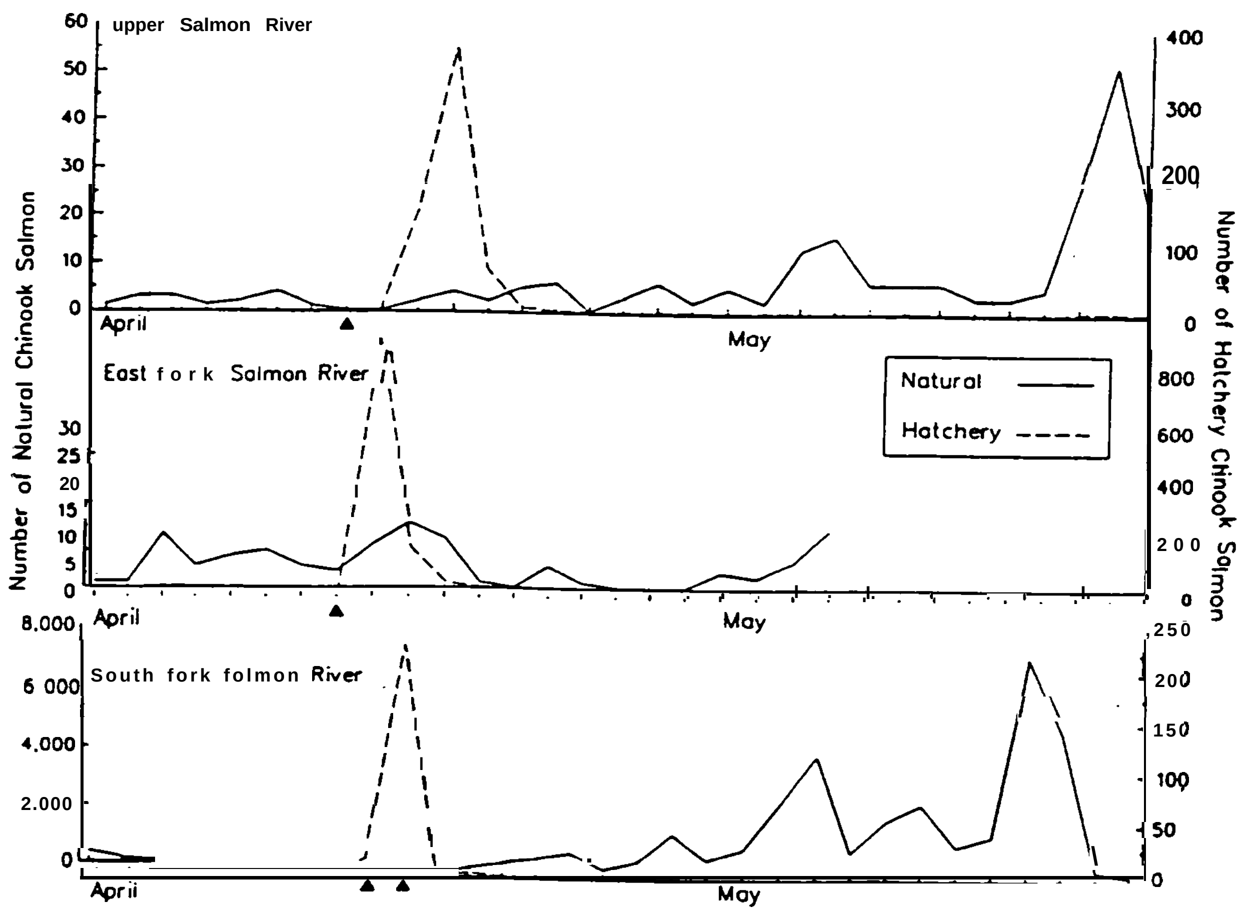

Figure 2. Record of natural and hatchery chinook salmon smolts collected at screw traps on the upper Salmon River, East Fork Salmon River, and South Fork Salmon River following smolt releases, spring 1993. Triangles indicate release dates. Data provided by Russ Kiefer (IDFG), and Robb Keith (Shoshone-Bannock Tribe Fisheries), and Eric Leitzinger (IDFG), respectively.

period did not change significantly, and averaged eight fish per day as compared to 5.2 fish per day for the previous five day period (Chi-Square P > 0.1).

The hatchery chinook salmon smolts released in the spring of 1993 moved downstream out of the three Salmon River systems soon after release. Most of the smolts moved past downstream traps in three days on the East Fork (possible range of 2.7-13 km/day) and in five days on the upper Salmon River (possible range of 1.6- 16.5 km/day). The migration rates we observed are similar to those of Atlantic salmon smolts which descended downstream in four days following their release (Hanson and Jonsson 1985).

Increased activity and movement of natural fish in the presence of hatchery fish has been observed previously (Hanson and Jonsson 1985; Hillman and Chapman 1989), as well as in experiments we conducted this year (see Size-density experiments). Premature downstream movement by natural chinook salmon, induced by the presence of hatchery fish, may be detrimental to natural fish if the proper migration conditions (i.e. flows, water temperatures. food supply) do not exist.

We observed a slight increase in the number of natural chinook salmon collected in the East Fork Salmon River screw trap at the time of out-migration of the hatchery smolts. but such was not the case in the upper or South Fork Salmon rivers. The gradual increase in the number of natural fish moving downstream in the South Fork Salmon River following the release of hatchery smolts appeared to be the natural onset of the spring emigration. The hatchery smolts released in the South Fork Salmon River moved a short distance (1 km) before reaching the screw trap, which limited the number of natural chinook salmon that may have been affected by their presence. Hatchery fish released into the upper Salmon River, however, moved up to 33 km, over known spawning and rearing areas, before reaching the downstream trap without producing a noticeable effect on the natural chinook salmon emigration.

One rational for releasing smolt-sized salmon and steelhead is that these fish will move out of the system soon after release, minimizing the possible interactions with resident natural fish stocks (Steward and Bjomn 1990). Our observations, and the trapping records. support the theory that hatchery smolts move downstream rapidly after release. Interactions between natural and hatchery chinook salmon in the release area appear to be minimal as a result of the rapid emigration.

Dispersion of Parr.

Chinook salmon parr from Clearwater Hatchery were released in four streams in 1993, two streams with single release sites and two using multiple release sites. On 5 August, 12,000 chinook salmon parr were released 4 km upstream from the mouth of Squaw Creek. On 6 August, 12,000 chinook salmon parr were released 4 km miles upstream on Pete King Creek. During 5-7 August, 80,000 chinook salmon parr were released, via helicopter drop, into a 5 km section of White Sands Creek starting at about 22.5 km upstream from the mouth of the creek (Powell fish trap). During this same period, 40,000 chinook salmon parr were dropped into a 1.6 km section of Big Flat Creek, between 27 and 29 km upstream from the Powell fish trap. All four streams are tributaries of the Lochsa River (Figure 1). A total of 16 snorkel transects were established on Squaw Creek, 12 on Pete King Creek, 12 on White Sands Creek, and three transects on Big Flat Creek (see Appendix A for description of study area) to monitor the dispersion of the hatchery fish. These transects were snorkeled one week and 24 hours previous to stocking and then again 24 hours, one, two, four, and six weeks following the releases.

Results and discussion. - No natural chinook salmon were found in Squaw, Pete King, White Sands, or Big Flat creeks prior to stocking of the hatchery fish in early August. In Squaw and Pete King creeks, the two streams with single release sites, hatchery chinook salmon were sighted at snorkel transects down to the mouth of both creeks 24 hours following their release (Figure 3). This is in contrast to the results seen in 1992 in Squaw Creek where the released parr were not seen in the lower stretch of stream until early fall. Highest densities of hatchery chinook salmon were found within 0.3 km of the release sites and decreased downstream to the creek mouths. There was little upstream movement from the stocking sites in Pete King and Squaw creeks. Hatchery fish densities in Squaw Creek were higher than those seen in Pete King Creek. Fish densities in Squaw Creek for 24 hours, one, two, four, and six weeks after release averaged ***0.89, 0.49 0.37, 0.40.*** and ***0.02*** fish/m2, respectively, versus 0.18, 0.12, 0.13, 0.06, and 0.01 fish/m2, respectively, in Pete King Creek. The hatchery chinook salmon had mostly left Squaw and Pete King creeks by the last snorkel date, 21-22 September (six weeks after release), when water temperatures dropped below 8°C.

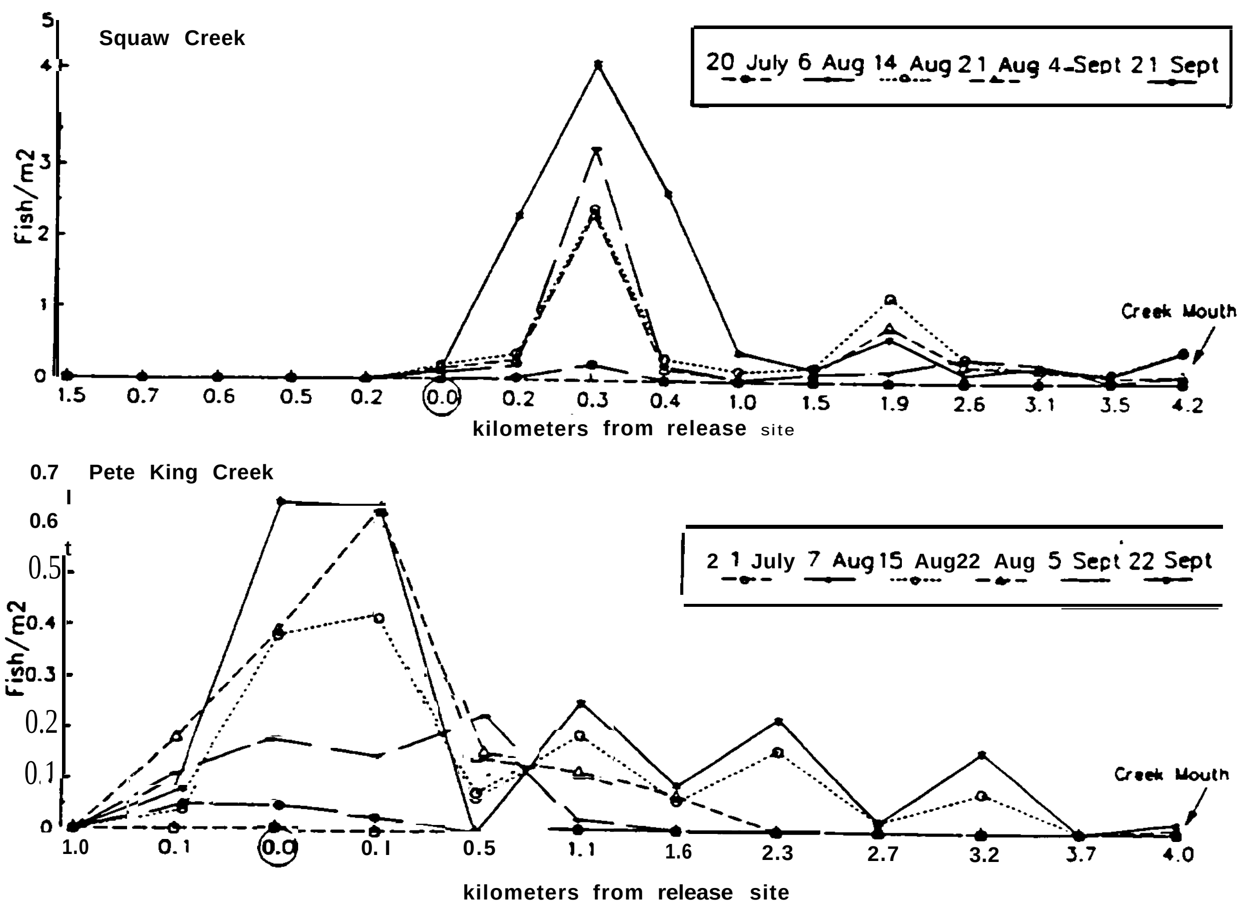

Figure 3. Densities of hatchery chinook salmon parr in Squaw and Pete King creeks in 1993, and locations of snorkel transects relative to the release site. Release sites-are circled on X-axis. Note that transect locations on X-axis are not equally spaced.

Hatchery chinook salmon parr were released throughout a 5 km section of stream in the headwaters of White Sands Creek, and in the upper l-2 km section of Big Flat Creek (see Appendix A). However, 24 hours after completion of the releases the hatchery parr were found only in the lower 0.5 km of the 5 km release area and in the 1.6 km stretch of stream just downstream from the release area in White Sands Creek (Figure 4). Hatchery fish were also sighted in White Sands Creek at the large pool located near Colt Creek Cabin, approximately 6.5 km downstream from the release area (WSO in Figure 4). The three snorkel transects we used in Big Flat Creek were located in the first 1 km near the creek mouth, about 4 km downstream from the release area (Figure 4). The hatchery pax-r were first observed in these transects on 14 August, one week after their release into the he&waters of the stream.

Densities of hatchery chinook salmon observed in White Sands Creek were lower than those seen in Squaw Creek, but similar to those in Pete King Creek. Fish densities in White Sands Creek one, two, four, and six weeks following release averaged 0.18, 0.18, 0.04, and 0.0 fish/m2, respectively. The hatchery chinook salmon parr had mostly left White Sands and Big Flat creeks by late September, corresponding to the out-migration of hatchery parr from Squaw and Pete King creeks. Twenty-four hours after their release into Squaw and Pete King creeks, chinook salmon parr were found 4 km downstream at the mouths of both creeks. Parr densities, however, remained highest within 0.3 km of the release sites through the summer and early fall.

In 1992, 10,000 chinook salmon parr released into Squaw Creek at a site near the release site used in 1993 also remained concentrated near the release site through the summer, but the densities were higher (average density one week after release = 1.09 fish/m2 in 1992 versus 0.49 fish/m2 in 1993) and the fish were not seen at the mouth of the creek until September in 1992. The chinook salmon released in 1993 averaged 13.0 g each (35 fish/lb), whereas the fish released in 1992 were much closer to the target release size of 9.0 g (50 fish/lb). Environmental conditions (i.e. habitat abundance, fl ows, water temperatures) appeared similar

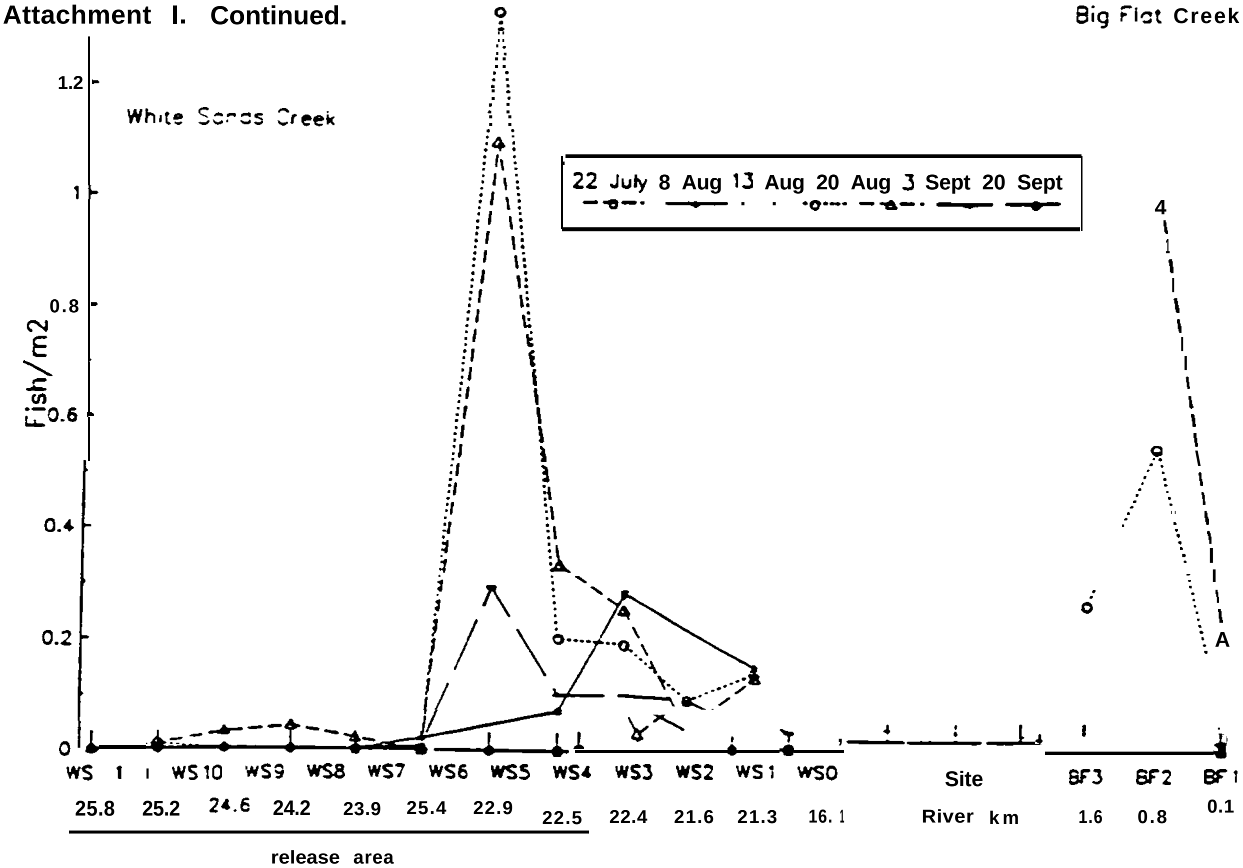

Figure 4. Densities of hatchery chinook salmon parr in White Sands and Big Flat creeks in 1993. and locations of snorkel transects relative to the river km. Sore that transect locations on X-axis are not equally spaced.

for the two years. so it may be that the larger fish size induced the quicker downstream dispersion we saw in 1993.

Fish densities in Squaw Creek were higher than those observed in Pete King Creek, although both creeks received the same number of fish in similar lengths of stream. The two streams are of simiiar size. Our snorkel transects in Squaw Creek averaged 6.4 m wide and 0.37 m deep, as compared to 7.5 m wide and 0.36 m deep in Pete King Creek. But, Pete King Creek is at a lower elevation, and had water temperatures 2-3^{o}C warmer, than Squaw Creek. Pete King Creek was also noticeably more turbid than Squaw Creek. These, or other factors. may have accelerated emigration of the hatchery fish from Pete King Creek. resulting in the lower observed parr densities.

Chinook salmon parr released at multiple sites within in White Sands Creek had left the stocking area soon after release. Characteristics of the stocking area, (e.g. sand substrate, gradient, food abundance) may have influenced the exodus of the hatchery fish.

The low dispersion rates of hatchery salmonids has been observed in other systems (Hume and Parkinson 1987; Hillman and Chapman 1989), including chinook salmon fry released into the Yankee Fork Salmon River (Richards and Cernera 1989). High concentrations of hatchery-reared fish persisting for extended periods of times may exceed the carrying capacity of a stream, limiting food and rearing habitat, and reduce the production potential for the resident and hatchery fish stocks alike (Hume and Parkinson 1987; Steward and Bjomn 1990). In the present study, the hatchery chinook salmon parr did not disperse evenly from the single release sights in Squaw and Pete King creeks, but moved quickly downstream from plantings made at multiple release sites in White Sands Creek. It is unknown what caused the observed exodus of parr from upper White Sands Creek, but factors such as food density, substrate type, fish size, water temperatures, and water quality may influence the rate at which dispersion occurs. In 1994 we hope to further investigate this question by closely monitoring the fish during and directly following the stocking events. At this time we can not draw conclusions on the use of singIe versus multiple release sites for improving parr dispersion.

Size-Density Experiments.

As stated previously, two factors important to evaluating a supplementation project are the survivability of the hatchery fish and any possible negative impacts they will have on the existing fish populations in the receiving waters. Our major focus for the small-scale studies in 1993 was to investigate the importance of fish size and density on the potential interactions that occur between hatchery and naturally produced chinook salmon, and how these interactions may influence the productivity of the juvenile chinook salmon in a natural setting. To accomplish this, experiments were run in the flume located at the Hayden Creek Research

Station. The flume was divided into 12 equal sections, 3.7 m long, 1.8 m wide, and 1.2 m deep and built to mimic a natural riffle-pool-riffle complex (Figure 5). Cobble, gravel, brush bundles, and overhead cover were added to each section to imitate a natural stream setting.

The experimental trials consisted of placing various numbers of hatchery and/or natural chinook salmon into the artificial stream sections for two week periods, during which observations were made of fish numbers and behavior through view ports in the sides of the flume. For these trials, the natural fish would be added to the flume first, and two days later the hatchery fish were "stocked" into the stream sections already holding natural fish. Observations were then made for ten days, three or four times a day, to examine habitat use, feeding, and aggressive behaviors of the hatchery and natural fish. Traps built into the

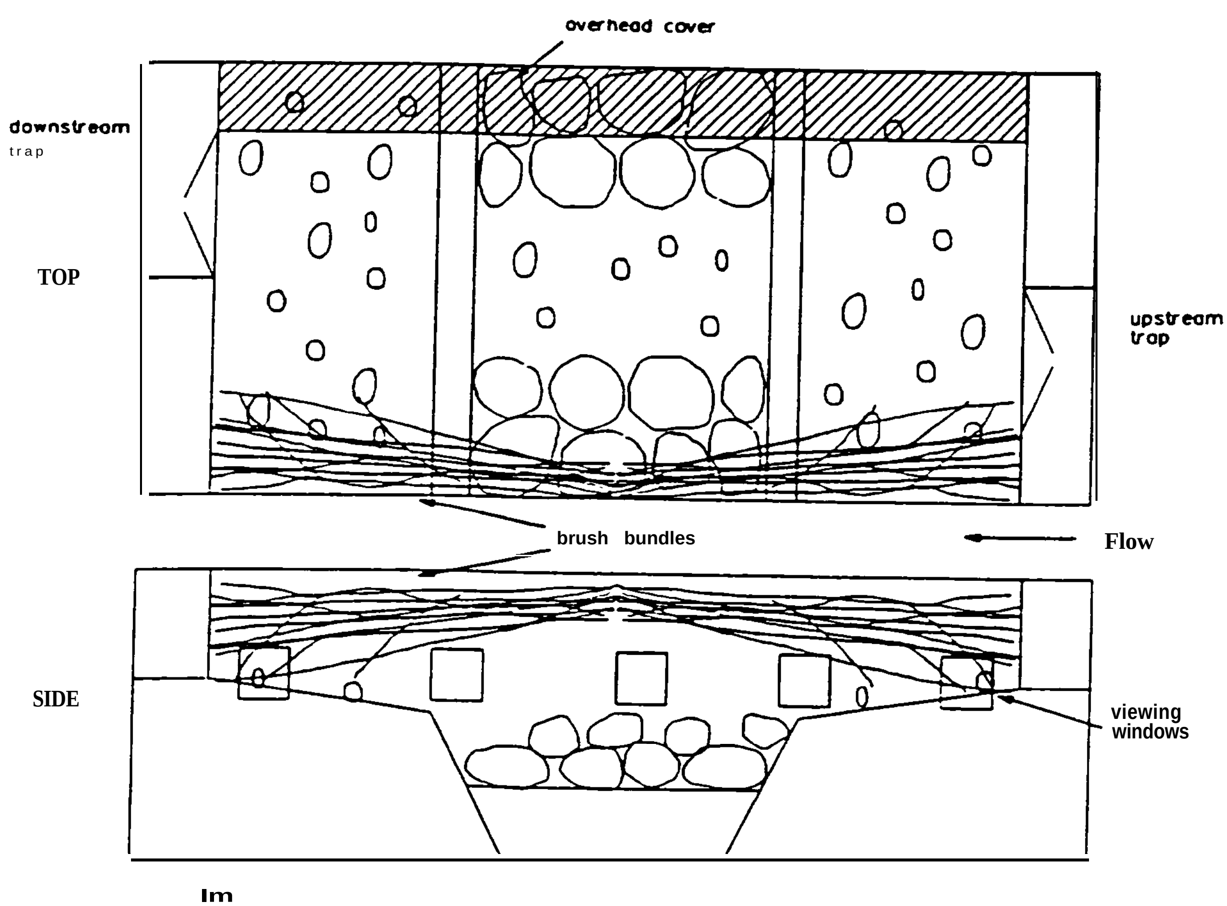

Figure 5. Artificial stream sections used for flume studies experiments. Pool area = 6.6 m2.

upstream and downstream ends of each section were emptied daily to monitor voluntary emigration patterns. The treatments used during the trials were as follows, (1) hatchery fish alone, (2) natural fish alone, (3) equal numbers of hatchery and natural fish, or (4) twice the number of hatchery fish as natural fish. During any one trial we could only use three of the treatments together, to allow for adequate replication (see below). The experiments were repeated over time to study the hatchery-natural interactions as both groups of fish increased in size.

We had hoped to mn experimental trials from the spring through the winter of 1993, but the low number of natural fish we were able to collect limited us to four trials, two in the fall and two in the winter. During the first trial (Fall-l), the treatments included natural fish alone, hatchery fish alone, and equal densities of hatchery and natural fish. A total of 60 fish were placed into each of the twelve sections (9 fish/m2) for this trial. In the second and third trials (Fall-2, Winter-l), the three treatments included 30 natural fish with either 0 (4.5 fish/m2), 30 (total density = 9 fish/m2), or 60 (total density = 13.6 fish/m2) hatchery fish per pool. In the last trial (Winter-2) we filled three pools with 60 natural fish for one week of observations, and then added 60 hatchery fish (18 fish/m2) for a second week of observations. We used this last trial to determine if established natural fish would be induced to leave the flume following the addition of the hatchery fish. Four replicates were made of treatments used for the two Fall trials and three replicates were made during the two winter trials.

Hatchery chinook salmon used for the trials were provided from Rapid River Hatchery, Riggins, Idaho, and the natural fish were collected from the Lemhi River using the downstream migrant trap located at the Lemhi River weir (see trapping procedure for PIT tag study, below). The natural fish were held in a fiberglass trough until enough fish had accumulated to run a trial, up to two weeks. All natural fish were fed aquatic insects, mostly Gamerus sp., prior to and during the trials. Hatchery fish were fed pelletized commercial fish food prior to a trial, and natural food items during a trial. The hatchery fish used for the trials were marked with a small clip to the upper caudal lobe to differentiate them from the natural fish during observations. Following a trial, the hatchery fish *were* moved to holding tanks and the natural fish were PIT-tagged and returned to the Lemhi River (see PIT tag study, below). .We used only naive fish for the experiments to eliminate learned-behavior bias in later trials.

Data Collected and Analyses.

Data collected from each experimental trial included the average weight change per fish from a stream section, emigration, aggression, and habitat selection. Growth was determined by weighing each fish at the start and end of each trial and averaged for fish type (hatchery or natural) in each flume section. Emigration was the proportion of each fish type leaving a stream section by the end of a trial. Aggression exhibited by the chinook salmon during experimental trials were recorded for each treatment during periodic ten minute observation periods. The aggressive encounters included obvious displays. charges. chases, and nips. and were classified according to the aggressor/aggressee pair as hatchery-hatchery, hatchery-natural, natural-hatchery, or natural-natural. Total aggression produced and received by each fish type was determined from these surveys. The aggression rates were calculated as the number of encounters counted per aggressor fish per minute during an observation period.

Habitat selection by the hatchery and natural chinook salmon within each flume section was recorded during the daily observations by assigning individual fish to one of 14 cells according to habitat type. The 14 habitat types included:

(1) riffles with overhead cover (simulated undercut bank),

(2) riffles adjacent to overhead cover,

(3) open riffles,

(4) riffles adjacent to in-stream cover,

(5) riffles with in-stream cover (brush bundles),

(6) upper pool water column with overhead cover.

(7) upper pool water column adjacent to overhead cover,

(8) open upper pool water column,

(9) upper pool water column adjacent to in-stream cover,

(10) upper pool water column with in-stream cover,

(11) lower pool water column with cobble substrate and overhead cover,

(12) lower pool water column with cobble substrate adjacent to overhead cover,

(13) open pool lower water column with gravel and silt substrate.

Fish not observed during an observation period were assumed to be exhibiting cover-seeking behavior (e.g. within the interstitial spaces of the pool cobble substrate) were assigned a fourteenth category. The number of each fish type (hatchery or natural) found in one habitat type was divided by the total number of fish of that type present in the stream section to obtain the proportional use of each habitat cell. Proportional habitat use was then scaled to the area in the artificial stream sections containing that habitat type. These values were arcsine-square root transformed to normalize the data.

Analysis of variance (ANOVA), using SAS statistical package (SAS Institute Inc 1990), was used to test for differences in aggressiveness, and aggression received between the two fish types and at the four treatment levels. ANOVA was used to test for significant changes in weight for each fish type during a trial, and analysis of covariance (ANOCOVA) was used to identify differences in growth rates between fish types, using initial fish weight as the covariate. The emigration data was analyzed using Chi-square contingency tables. A repeated measure ANOVA was used to test for differences in the use of the 14 habitat types by treatment level and fish type. Proportional habitat use was averaged across the daily observations, and Day (l-10) became the repeated measure variable in the analysis. When no significant difference was detected with respect to the repeated variable (within-subject effects) the data was averaged across the repeated variable and a univariate ANOVA analysis was run for the between-subject effects. In all cases no significant differences were detected in the outcomes of the repeated measures and univariate analyses.

In the cases were habitat-use patterns varied over the repeated variable, the between-subject effects were tested separately on the similar day-groups. Comparisons of means were made using Tukey's Standardized Range Test, and all tests were evaluated for significance at the alpha = 0.05 level.

Results and Discussion.

Salmonids reared in hatcheries are subjected to selective pressures divergent from those existing in the natural environment. These selective pressures produce fish which are genetically and behaviorally altered from their natural counterparts (Vincent 1960; Reisenbichler and McIntyre 1976: Sosiak et al. 1979; Bachman 1984; Chilcote et al. 1986; Leider et al. 1988; Hindar et al. 1991; Waples 1991). The purpose of this segment of the study was to determine the types of interactions possible between hatchery and naturally produced chinook salmon, and to identify, if possible, the effects of these interactions on the survival of the natural stocks.

We had hoped to run experimental trials with fish ranging from fry in the spring, to pre-smolts in the fall and winter. But, due to the low number of natural fish we were able to collect, the experimental trials were limited to two in the fall and two during the early winter months (Table 1). A second limitation was the size of the natural fish available for our use. In all trials, the hatchery chinook salmon used were smaller than natural chinook salmon. The natural chinook salmon juveniles averaged 6-l 1 mm and 2-4 g larger than the hatchery chinook salmon. Typically hatchery-reared chinook salmon are larger than the naturally produced salmon when stocked as sub-yearlings. The water temperatures and productivity of the Lemhi

River. however, promotes faster growth of chinook salmon juveniles than do most streams in Idaho, resulting in the large natural fish used during these trials. The results presented here should be viewed with this limitation in mind.

Table 1. Dates, average water temperatures, and the initial fork lengths and weights of the hatchery and natural chinook salmon used in the six experimental trials.

Trial	Dates	Temperature °C	Initial length & weight Hatchery	Natural
Fall I	28 Sept-1 1 Oct	10.0	100.4 mm 12.7 g	111.5 mm 16.8 g
Fall II	14 Ott-27 Oct	*7.0*	103.3 mm 13.7 g	109.2 mm 15.3 g
Winter I	3 Nov- 15 Nov	2.3	99.3 mm 11.4 g	107.3 mm 13.8 g
Winter II	19 Nov-2 Dec	1.5	101.0 mm 12.0 g	110.0 mm 16.2 g

Results are presented here for emigration behavior (proportion of fish leaving stream section) , growth, aggression, and habitat use by the two fish types (hatchery or natural) and the four treatment levels. All four trials conducted in 1993 had significant interactions between fish type and treatment level, requiring that each treatment and fish type pair be tested separately.

Emigration. - In general, emigration from the flume sections was similar for the hatchery and natural chinook salmon within trials and treatment levels (Table 2). There was no significant difference in the emigration of natural chinook salmon with or without hatchery fish present. An average of 25% of the fish left the stream sections in the first fall trial. During the second fall trial the average emigration for all fish declined significantly to 10.8% (Chi-Square, $P < 0.001$) at the lower water temperature (7°C). In the first winter trial, with lower water temperature (2.3°C), an average of 20% of the hatchery fish left the sections versus

Table 2. Emigration, average growth, and aggression (aggressive encounters/fish/minute) for chinook salmon in four size-density trials. Treatments = (1) hatchery fish alone, (2) natural fish alone, (3) and (3) hatchery fish and natural fish together with variable numbers. S-S = aggression towards same fish type. S-D = aggression towards different fish type. Total aggression = sum of S-S and S-D aggression. Received = total aggression received by fish type. N = 4 for the two fall trials and n = 3 for the two winter trials. Values in parentheses are standard deviations.

Trial	Treat-ment	Fish type	Start No.	Percent leaving	Average growth(g)	Aggression S-S	Aggression S-D	Aggression Total	Aggression Received
Fall-1									
	1	Hat	60	25 (0.13)	-0.15 (0.42)	0.20 (0.19)		0.20 (0.19)	0.20 (0.19)
	2	Nat	60	23 (0.16)	0.43 (0.67)	0.09 (0.03)		0.09 (0.03)	0.09 (0.03)
	3	Hat	30	27 (0.19)	-0.33 (0.17)	0.52 (0.15)	0.20 (0.14)	0.71 (0.25)	0.71 (0.14)
	3	Nat	30	26 (0.13)	-0.05 (1.02)	0.13 (0.14)	0.06 (0.05)	0.19 (0.18)	0.39 (0.30)
Fall-2									
	2	Nat	30	07 (0.06)	-0.53 (0.25)	0		0	0
	3	Hat	30	16 (0.13)	-0.70 (0.26)	0.32 (0.18)	0.08 (0.07)	0.40 (0.23)	0.39 (0.12)
	3	Nat	30	11 (0.08)	-0.60 (0.27)	0.03 (0.04)	0.07 (0.04)	0.10 (0.05)	0.20 (0.21)
	4	Hat	60	12 (0.08)	-0.83 (0.26)	0.30 (0.14)	0.04 (0.03)	0.34 (0.15)	0.46 (0.36)
	4	Nat	30	08 (0.03)	-0.90 (0.08)	0.03 (0.04)	0.03 (0.03)	0.03 (0.03)	0.16 (0.13)
Winter-1									
	2	Nat	30	08 (0.11)	4.30 (0.52)	0		0	0
	3	Hat	30	17 (0.15)	0.13 (0.21)	0	0	0	0
	3	Nat	30	01 (0.02)	-0.03 (0.38)	0	0	0	0
	4	Hat	60	23 (0.01)	-0.07 (0.38)	0.16 (0.14)	0.02 (0.01)	0.17 (0.15)	0.16 (0.14)
	4	Nat	30	02 (0.02)	-0.53 (0.45)	0	0	0	0.07 (0.06)
Winter-2									
	3	Hat	60	15 (0.01)	0.17 (0.02)	0	0	0	0
	3	Nat	60	20 (0.15)	-1.03 (0.02)	0	0	0	0

3.8% of the natural fish (Chi-Square, $P < 0.001$). Significantly more hatchery than natural fish emigrated from those sections in which the.hatchery and natural fish were combined (Chi-square, $P < 0.05$). In the second winter trial, an average of 17.2 % of the natural fish left the sections by the end of the first week, at which time emigration had ceased. This was an increase from the emigration observed in the first winter trial (l-8%) when the loading density was 30 fish/pool versus 60 fish/pool during Winter-2. After the hatchery fish were added to the flume, at the start of the second week of observations, an additional 4.7% of the natural fish left the stream sections, for a total emigration of 20%. This increased emigration was associated with a general increase in activity within the stream sections by the natural chinook salmon (see section on habitat use). Fifteen percent of the hatchery fish left the stream sections during the second week of this trial.

There is concern that the presence of hatchery fish may increase the emigration of natural fish out of a system, either by habitat displacement or by an attraction to join the hatchery fish (Steward and Bjornn 1990). During these experimental trials, we saw no effect on the emigration of natural chinook salmon from the artificial stream sections related to the presence of hatchery fish during the fall and first winter trials. There was little difference between the emigration of hatchery or natural fish, except during the first winter trial. This is in contrast to the observation reported by,Hillman and Mullan (1989) that natural chinook salmon in the Wenatchee River left their normal stations and joined a group of hatchery fish near the stream center and near the surface, as the hatchery fish moved downstream. The movement of hatchery Atlantic salmon smolts may have increased the emigration of natural smolts (Hanson and Jonsson 1985), and similar observations were made for hatchery and natural chinook salmon smolts in the East Fork Salmon River during the spring 1993 (see section on hatchery chinook salmon dispersion).

The second winter trial was conducted to determine if the natural chinook salmon could be induced to emigrate from the stream section at higher fish densities. During this trial, hatchery fish were added only after the natural fish had stabilized and all emigration from the stream sections had ceased. The week following the addition of the hatchery fish, an average of nine hatchery fish (15%) and 1.7 natural fish (3.4%) left the three stream sections. This slight increase in emigration by the natural fish is consistent with the idea suggested by Hillman and Mullan (1989) and Hanson and Jonsson (1985) that hatchery fish may have a drawing-out or displacement effect on natura.l fish. However, the additional emigration of natural fish we observed may have resulted from density effects.

Emigration, like most of the behaviors we observed, decreased with water temperatures. Average emigration from the sections in the first versus the second fall trials declined by more than half with an average water temperature decline of 3°C. When water temperatures declined further to near freezing in the winter trial the natural fish responded by again decreasing emigration, but the hatchery fish increased emigration. This may represent a differential behavioral response to extreme temperature changes by the two fish types.

Growth. - The two week period of each experimental trial was sufficient to produce measurable growth changes for the chinook salmon, principally determined by average weight change per pool section. In general, the average weight of the fish remained the same or declined during a trial (Table 2).

There was no significant difference in the starting and ending weights for the hatchery or natural fish in the first fall trial. There was a significant difference ($P = 0.0128$) between the slopes of the growth curves for the hatchery and natural fish when the two fish types were separate.

During the second fall trial there was a significant decline in the weights of the both the hatchery and natural chinook salmon at the highest loading density (treatment 3; natural $P < 0.001$, hatchery $P = 0.043$). The average weight of natural chinook salmon declined by 0.9 g while the hatchery fish declined by an average of 0.83 g per fish. Differences between the starting and ending weights were not significant for the natural fish alone or for the hatchery and natural fish together at equal densities. The slopes of the growth curves for the natural fish alone and the natural fish with 60 hatchery fish differed significantly ($P = 0.0481$). The slopes of the growth curves of the hatchery fish at the low and high densities were not significantly different ($P = 0.1185$).

There was no difference in the start and end weights for the hatchery or natural chinook salmon from the first winter trial. The growth curves for the natural fish in the three treatments were also not different ($P = 0.088$). There was a significant difference in the growth curves between the hatchery and natural fish at the equal loading density (treatment 2, $P = 0.028$).

The natural chinook salmon in the second winter trial lost an average of 1.03 g over the two weeks, while the hatchery fish gained an average 0.17 g during the one week they were in the stream sections ($P = 0.007$). It is not known how much of the natural fish weight loss occurred before and after the hatchery fish were added.

Growth is a direct result of foraging success. Under normal circumstances the most efficient feeder will be the individual that gains the highest nutritional benefit with the least energy expenditure. Optimal feeding locations should thus be low water velocity areas near a high velocity area where a fish can lay in wait for drifting food items, and preferably near cover to provide protection from predators (Everest and Chapman 1972; Bachman 1984). Use of energy-costly behavior may be a major cause for the lower survival of hatchery fish following release into natural systems (Fenderson et al. 1968; Bachman 1984; Mesa 1991). During the trials we observed that the hatchery fish consistently made greater use of the swifter pool surface waters than natural fish when the two were combined (see below), and the hatchery fish were always the dominant fish at the head of the pool area. While this may not be the most efficient position, due to the amount of energy required to maintain position in the swifter current. it did assure first access by the hatchery fish to any food items entering the flume section. The amount of food available in the stream sections was intentionally kept low to imitate a food limiting condition as may exist in an infertile Idaho stream. When food items were added to a flume section, those fish at or near the surface (hatchery fish) were the first to respond. Of the fish not near the surface, the hatchery fish were quicker to respond to food entering the pool than the natural fish. Our inability to detect significant differences in the growth patterns at the different fish densities may have been due to the short time span (14 days) of the trials. In 1994 we plan to conduct similar trials over longer time periods (l-2 months) in order to better evaluate the effects of density and food availability on natural and hatchery chinook salmon growth rates.

Aggression.- Hatchery chinook salmon were significantly more aggressive than natural chinook salmon, and they were more aggressive towards other hatchery fish than towards natural fish. Natural fish also exhibited aggression. but there was not a difference in the amount of aggression towards hatchery or other natural fish. Natural fish did not receive more aggression when combined with the hatchery fish. Aggression declined. along with general activity, at the lower water temperatures (Table 2).

During the first fall trial, the hatchery fish initiated and received more aggression when combined with natural fish than when alone (aggression initiated $P = 0.016$. aggression received $P = 0.006$). The natural fish did not receive more aggression in the presence of the hatchery fish than when alone ($P = 0.09$). The power for the natural fish analysis was 0.55. and we would have required $n = 10$ to detect a significant difference at a power of 0.80. The hatchery fish were significantly more aggressive than the natural fish when the two were combined ($P = 0.016$). Aggressive encounters declined from an overall average of 0.3/fish/minute during the first fall trial, to O.l/fish/minure in the second fall trial. with a three degree drop in water temperature.

Natural fish were more aggressive when hatchery fish were present than when alone during the second fall trial (P = 0.013), but the aggression received was not significantly higher (P = 0.16). Aggressiveness of the hatchery fish did not vary between the low and high densities. During the first winter trial, aggression was observed only for hatchery fish at the higher loading density, and no aggression was observed during the second winter observation.

The type of aggression used by the hatchery fish was more vigorous, and the territory defended by an individual fish was larger, than that of the natural fish, based on our visual observations. Hatchery fish were more likely to charge, chase and nip at other fish, while the natural fish predominantly used displays and feints in their encounters.

Within one to two days after the introduction to the stream section, the chinook salmon would establish and defend territories. The size of the territory depended on the aggressiveness of the individual fish, and varied between a small envelope surrounding a fish, up to one third of the pool area in a stream section. There were two different patterns of movement within a stream section resulting from the aggressive behavior of the fish. First, fish defending a territory tended to remain in that area until another fish successfully moved it off position. The second pattern was for those fish without territories, that continually moved around in the stream sections. These roaming fish were consistently chased off as they entered other fish's territories, until they were either able to successfully take over an existing territory, or to find a location that was not already claimed. The areas of the stream section defended the most vigorously (mainly by hatchery fish) were in swift water at the head of the pool, just off the riffle, and adjacent to the overhead cover. The territory defended by these dominant fish was relatively large, usually including the upstream riffle which was kept cleared of other fish. It was the fish in these areas from which the majority of aggressive encounters were seen during an observation period.

Hatchery salmonids have been observed to be more aggressive than their natural counterparts (Bachman 1984; Chandler and Bjornn 1988; Swain and Riddell 1990; Mesa 1991:

Dewald and Wilzbach 1992), but it is unknown what produces this overt aggressiveness. From our observation it is obvious that a great deal of energy is expended by the most aggressive fish in order to maintain their large territories. The high food abundance and fish densities in hatcheries may tend to select for aggressive behavior (Swain and Riddell 1990). A second theory is that aggression is suppressed in hatcheries. Fish exhibiting such energy-wasteful behavior in a stream may learn to moderate aggressiveness or be selected against, but in a hatchery they are maintained, and the behavior becomes expressed only after these fish are pIaced in a natural system. It is unknown if hatchery fish can learn to be more cost effective, resulting in decreased aggressiveness with time. In 1994, we intend to study this aspect of hatchery fish behavior in experimental trials extended over one to two month periods.

Habitat seiecnbn. - Habitat selection by chinook salmon within the riffle-pool-riffle units in the flume varied by fish type. treatment, and season. In general, the chinook salmon made highest use of the surface pool water (habitat unit 8) and cobble interstices (unit 14), and least use of the uncovered and overhead covered riffle areas (units 1, 2, 3 and 4) (Table 3 and see Figure 2). Natural chinook salmon made more use of the cobble cover and less use of the open pool surface water areas than the hatcher), fish. Use of cover increased significantly for both fish types as water temperatures decreased in the fall and winter. In the following results we will focus on where significant differences were found in habitat selection between the treatment levels and fish types.

The first fall trial contained three treatments; hatchery fish alone, natural fish alone, and the treatment containing equal numbers of natural and hatchery fish. Natural fish in the first fall trial made greatest use of the cobble cover (25.7%), the open pool surface (22.3 %), and the open pool bottom (20.7%) when alone (Table 4). Use of the cobble cover increased (39.6%), and use of the pool surface and pool bottom declined (11.6% and 9.1%. respectively) when combined with hatchery fish. The hatchery fish made greatest use of the

Table 3. Percent habitat use for the four size-density chinook salmon experimental trials. Treatments were (1) hatchery fish alone (2) natural fish alone (3) equal numbers of hatchery and natural fish and (4) twice the number of hatchery as natural fish in each riffle-pool-riffle unit. Numbers in column headings refer to the 14 habitat types as described in the methods section.

								Pool surface				Pool bottom			
Trial	Cobble treatment	Fish type	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Fall-1																
	1	Hat	2.0	0.9	1.8	1.5	3.3	7.7	16.3	26.5	10.4	4.9	1.8	5.3	11.5	6.2
	2	Nat	0.6	0.3	0.8	0.6	2.2	2.2	6.7	22.3	6.1	1.7	2.5	7.5	20.7	25.7
	3	Hat	1.9	0.6	2.9	2.7	6.4	7.6	11.4	16.3	9.1	7.9	2.9	5.2	14.3	11.0
	3	Nat	0.3	0.3	1.4	1.7	3.6	0.6	3.0	11.6	13.0	6.4	2.8	6.6	9.1	39.6
Fall-2																
	2	Nat	0.04	0.07	0.1	0.2	6.6	0.4	0.2	1.8	0.3	2.6	0.4	0.4	1.8	85.0
	3	Hat	1.9	0.1	0.5	1.4	9.0	9.9	14.4	17.3	4.7	6.9	1.9	2.4	5.0	24.6
	3	Nat	0.3	0.06	0.06	0.9	3.3	1.8	4.5	11.6	7.1	5.9	0.9	3.3	5.9	54.0
	4	Hat	0.10	0.02	0.7	0.1	4.0	11.4	11.6	30.4	6.9	4.7	0.1	3.0	6.9	17.3
	4	Nat	0.08	0.2	0.6	0.8	2.3	2.3	4.2	14.1	8.8	2.8	0.8	9.0	7.9	46.0
Winter-1																
	2	Nat	0.0	0.0	0.0	0.0	4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	95.6
	3	Hat	0.0	0.1	0.2	4.3	44.2	4.0	0.0	0.1	1.3	5.9	0.1	0.0	0.2	39.9
	3	Nat	0.0	0.0	0.0	0.08	4.7	0.0	0.0	0.0	0.0	0.4	0.1	0.3	0.1	93.8
	4	H	0.3	0.1	0.1	0.3	6.3	13.6	7.8	26.0	1.3	1.8	0.8	0.8	2.8	38.3
	4	Nat	0.1	0.1	0.0	0.0	4.6	1.4	3.2	3.6	0.7	2.1	0.7	0.7	1.4	81.3
Winter-2																
	2	Nat	0.0	0.0	0.0	0.0	6.3	0.0	0.4	5.2	0.0	0.3	0.4	0.7	0.7	85.9
	3	Hat	0.2	0.03	0.0	0.0	11.1	9.8	24.6	32.9	1.5	0.8	0.2	1.9	5.1	12.0
	3	Nat	0.07	0.0	0.0	0.3	0.06	0.0	2.3	7.2	6.8	0.7	1.4	3.1	4.4	73.4

open pool surface (26.5%), after which the pool bottom (11.5%), and pool surface adjacent to the overhead (16.3%) and instream covers (10.4%) were used at similar rates. There was no difference in habitat selection by hatchery fish when alone or when combined with natural fish.

In general, the hatchery fish made significantly more use of the open pool surface, pool surface adjacent to and under overhead cover, and less use of the cobble cover than the natural fish.

The second fall trial contained three treatments; 30 natural chinook salmon alone, 30 natural and 30 hatchery fish together, and 30 natural and 60 hatchery fish together. When natural chinook salmon were alone, 85% of the natural fish selected cobble cover. The next highest used habitat was the instream cover at 6.6%. The natural fish made significantly less use of the cobble and instream cover and increased use of the pool surface and pool bottom when hatchery fish were present. Habitat selection by the natural fish did not differ between when 30 or 60 hatchery fish were present. Hatchery fish used mostly the cobble cover and then the open pool surface when 30 of each fish type were present. but the order of importance of these two habitats reversed in the sections with 60 hatchery tish and 30 natural fish. As in the first trial, hatchery fish made more use of the pool surface, including the overhead cover. and less use of the cobble cover than the natural fish when the two fish types were combined.

The first winter trial contained the same combinations of hatchery and natural fish as the second fall trial. Habitat selection for the natural fish was the same whether alone or combined with 30 hatchery fish, with 95.6% and 93.8%, respectively, of the fish using the cobble cover and little use of the other habitat. When the natural fish were combined with 60 hatchery fish, most of the natural fish were still using the cobble cover (81.3%), but there was a significant increase in the use of the open pool surface habitat (from 0% to 3.6%) compared to when there were no or 30 hatchery fish present. There was a decline in the use by hatchery fish of riffle-instream cover from 44.2% to 6.3%, and an increase use of the open pool surface from 0.1% to 26.0% between the low and high hatchery fish densities. With 30 hatchery fish present, the hatchery fish made greater use of the riffle-instream cover and less use of the cobble cover than the natural fish With 60 hatchery fish present, the hatchery fish made greater use of the overhead cover and pool surface, and less use of the cobble cover than the natural fish.

For the second winter trial we made observations on three pools, containing 60 natural fish each, for one week. After one week of observations 60 hatchery fish were added to the three pools and observations were made for an additional week. There was a significant increase in use by the natural fish of the open pool surface, open pool bottom, and pool bottom adjacent to the overhead cover after the hatchery fish were added. In the second week of observations the hatchery fish made more use of the riffle-instream cover, pool overhead cover, and pool surface, and less use of the cobble cover than the natural fish.

Habitat selection by the chinook salmon varied by fish type, treatment, and season. In general, the natural fish preferred the pool surface, pool bottom, and the cobble substrate. The hatchery chinook salmon preferred the pool surface and bottom areas. Use of cover increased for both types of fish with decreased water temperatures.

At average water temperatures of 10°C, the natural fish made less use of the pool area and more use of cobble substrate cover in the presence of the hatchery fish. The hatchery fish maintained greatest use of the pool surface regardless of the presence of natural fish,

At an average water temperature of 7°C, use of cobble and riffle-instream cover by the natural fish declined concurrent with increased use of those habitats by the hatchery fish. The number of natural fish using the cobble cover when alone in the stream sections averaged 25.5 fish (85%). When 30 hatchery fish were present, the number of fish using the cobble cover averaged 7.4 hatchery and 16.2 natural (total = 23.6). When 60 hatchery fish were present, the numbers using the cobble averaged 10.4 hatchery and 13.8 natural fish (total = 24.2). A similar pattern was observed with the instream cover use. It appears that the natural chinook salmon were being displaced from their preferred habitat by the hatchery fish. Whether a portion of the natural chinook salmon were leaving the cover and were replaced by the hatchery fish, or they were being forced from the cover habitat by the hatchery fish can not be determined.

When water temperatures averaged 2.3°C, there was significantly increased use of the pool area associated with a slight (non-significant) decline in the use of the cobble cover by the natural fish when hatchery fish were present. The effects of the hatchery fish on natural fish habitat selection were less severe here, possibly due to the increased emigration from the stream sections and the decreased aggressive activity by the hatchery fish at the lower water temperature.

Hatchery-produced saimonids have been observed to use different habitat than that of sympatric natural fish, and in most cases it was speculated that the divergence placed the hatchery fish at a competitive disadvantage (Soskial et al. 1979; Bachman 1984; Hillman and Chapman 1989). There has been little evidence that supports the idea that hatchery fish can displace natural fish from their preferred habitat (Steward and Bjomn 1990), and it is possible that habitat use by the hatchery fish is determined by the competitive dominance of the natural fish. In the current study, however. the natural fish shifted habitat use significantly when combined with the hatchery fish. rather than the reverse. This agrees with the results reported by DeWald and Wilzach (1992) in which habitat selection by native brook trout in an artificial stream was altered when hatchery brown trout were present. Released chinook salmon fry and parr disperse slowly, resulting in locally high densities of hatchery fish (see Dispersion study). If hatchery fish are able to dominate the natural fish at these high densities, the result may be loss of the best feeding locations. decreased growth, increased exposure to predation, and in extreme conditions, elimination of the displaced natural fish from the system (Swam and Riddell 1990; Mesa 1991; DeWald and Wilzbach 1992). In 1994 we plan to investigate further chinook salmon hatchery-natural interactions and how aggression, habitat selection, and growth rates may vary over longer (l-2 months) time periods.

Predation Experiments

As part of the ISS project, chinook salmon will be re-introduced into drainages where they were previously abundant, and in which resident and non-resident trout stocks have since become established. During the predation experiments we attempted to assess the direct and in-direct effects of predatory trout on newly released hatchery-reared chinook salmon parr. Emphasis was placed on brook trout as predators since these non-resident fish typically inhabit headwater streams, which are rearing areas for age-0 chinook salmon juveniles.

The procedures for the predation trials were similar to the hatchery-natural interaction trials described above. In this case two treatments were used; hatchery fish alone and hatchery fish with adult brook trout predators. Prior to initiating a trial the brook trout were allowed to acclimate to the flume sections for one week. One brook trout was used per section as predators during the first trial, but this was increased to two brook trout per section during the second and third trials. Following the acclimation period, 60 hatchery chinook salmon parr were added to each flume section and the observations were begun. Observations were made three or four times a day for ten days, after which the trial was terminated and the number of fish remaining in each flume section was determined. The upstream and downstream traps were emptied daily to monitor emigration from the flume sections and observations of aggressive encounters were recorded. Growth rates of the hatchery chinook salmon,were determined by measuring the lengths and weights of each fish at the start and end of each trial. The brook trout used during these trials were collected from Texas Creek, at the headwaters of the Lemhi River and ranged in size from 170 to 245 mm fork length. The chinook salmon were provided by Rapid River Hatchery, Riggins, Idaho. Three predation trials were completed, during the spring, summer, and fall of 1993 (Table 4).

Data Collected and Analyses.

Data collected during the predator trials was similar to the hatchery-natural interaction trials described above. Habitat analysis was used to determine if habitat selection by the chinook salmon parr was altered when predators were present. Emigration, aggression, growth, and the number of fish missing from each section (presumably from predation) was analyzed for the differences between the two treatments using ANOVA and ANOCOVA procedures. Differences between means were determined using Tukey's Standardized Means test, and all tests were tested for significance at the alpha = 0.05 level.

Remits and Discussion.

Three predation trials were completed, one each in the spring, summer. and fall of 1993 (Table 4). The size of the hatchery chinook salmon increased significantly between each trial, while the average size of the predators remained around 200 mm (Table 4). We typically combined the largest with the smallest brook trout within sections so that the total length of the two predators were similar between flume sections, and there appeared to be no correlation between size of predators and predation rates. Water temperatures for the three trials were maintained at 1 l°C.

Table 4. Dates, average water temperatures, and the initial fork lengths and weights of the chinook salmon and brook trout predators for three predation trials. Values in parenthesis are standard deviations.

Trial	Dates	Mean temperature	Chinook salmon length & weight	Brook trout length
Spring	25 May-l 1 June	11.2 (0.73)	***54.9*** mm (0.54)	217.3 mm (22.7)
Summer	28 June- 16 July	11.1 (1.61)	***67.5*** mm (1.41) ***3.4 g (0.28)***	198.8 mm (28.6)
Fall	***3*** Sept-15 Nov	10.9 (2.37)	***83.3*** mm (0.88) 7.1 g (0.16)	***205.7*** mm (31.7)

There was no difference in the number of hatchery chinook salmon leaving the artificial stream sections with or without predators present in all three trials. There was no difference in the aggressive encounters observed in stream sections with or without predators present during the summer and fall trials (Table 5). Aggression counts were not made during the spring trial. During the summer trial the hatchery fish did not increase in size in the sections with predators present but did increase in average weight in the sections without predators. In the fall, the hatchery fish increased in size in the sections with and without predators present (Table 5). We were unable to determine growth of the hatchery fish in the spring trial due to technical difficulties.

Fish unaccounted for at the end of a trial may have been lost by jumping out of the flume, by working their way into cracks between boards in which the stream sections were constructed, through miscounts as fish were added or removed from the stream sections and traps, or from predation. Differences between the number of fish missing from the sections with and without predators present were attributed to predation by the brook trout. In all case there were more fish missing from the sections containing predators than the sections without predators present, but the difference was significant only for the summer trial (Table 5).

Table 5. Emigration, average growth, and aggression (aggressive encounters/fish/minute) for chinook salmon in three predation trials. Treatment 1 was hatchery chinook salmon with predators, treatment 2 was hatchery chinook salmon alone. Values in parenthesis are standard deviations, n = 4 for all three trials.

Trial	Treatment	Fish type	No.	Emigration	Growth(g)	Aggression	Missing
Spring	1	Hat	60	41.8 (6.6)			3.0 (2.2)
	2	Hat	60	31.5 (9.6)			1.5 (1.3)
Summer	1	Hat	60	32.0 (3.9)	0.75 (0.14)	0.41 (0.29)	0.3 (4.8)
	2	Hat	60	29.5 (9.3)	0.31 (0.33)	0.55 (0.20)	6.3 (0.5)
Fall	1	Hat	60	14.0 (4.3)	0.95 (0.17)	0.44 (0.07)	1.5 (1.3)
	2	Hat	60	18.0 (5.5)	1.03 (0.29)	0.68 (0.25)	0.3 (0.5)

In the spring trial a single brook trout was used per section (O.l5/m2). At the end of this trial there was an average of 3.0 fish missing from the sections containing predators versus 1.5 missing from the sections with no predators present (P = 0.28). During the summer trial we used two brook trout per treatment (0.3/m2), and the number of fish missing at the end of the trial increased to 6.3, versus O-3 in the sections with no predators present (P = 0.047, power > 0.95). Two predators were again used per section during the fall trial. For this trial there was an average of 1.5 fish missing from the sections containing predators and 0.3 missing from the sections with no predators present (P = 0.12). Habitat use by the hatchery fish varied little between the sections with and without predators present (Table 6). In the spring the hatchery chinook salmon made greatest use of the pool surface. The pool surface was still the preferred habitat type in sections with predators present, but the use was lower than without predators. There was not a significant increase in the use of cover habitat with the predator present. In the summer, the hatchery fish again made highest use of the pool surface. followed by the cobble cover, open riffle, and pool bottom areas. With predators present, there was a significant increases in the use of the pool overhead cover and pool surface adjacent to the overhead cover, and a decline in the use of the cobble cover. In the fall, the hatchery fish were found in highest numbers at the pool surface, and there was no difference in the habitat selection in the sections with or without predators present.

We ran three predation trials in 1993 with hatchery chinook salmon ranging in average size from 54.9 to 83.3 mm in length. The water temperatures for the three trials were maintained at 1 l°C so that the results could be comparable. We found few significant differences in the behavior of the hatchery fish with and without predators present. The hatchery fish in all three trials were found predominantly at the pool surface and in low numbers in the cover, and there was no change in the number of fish leaving a stream section, their growth, or aggression Ievels when predators were present. This is in contrast to the results of a similar study in

Table 6. Percent Habitat use for the three predatoin trials. Treatments were (I) hatchery chinook salmon with brook trout predators, and (2) halchery chinook salmon alone. Numbers in column headings are the I4 habitat classifications, as described in the methods section for size-density trials.

Trial	Treat-ment	Fish type	Riffle 1	2	3	4	5	Pool surface 6	7	8	9	IO	Pool bottom 11	12	I3	Cobble 14
Spring	1															
	2	Hat Hat	2.0 1.8	6.3 5.8	6.3 5.3	0.9	2.9 0.9	6.4 7.1	25.4 34.4	20.0 13.2	5.4 1.8	4.3 2.4	2.7 2.4	5.4 8.7	4.9 3.8	7.0
																IO.5
Summer	1												1.1	....	....	
	2	Hat Hat	0.9 1.1	4.7 4.9	8.0 5.9	2.2 1.9	1.7 1.5	4.7 6.9	15.9 19.6	27.3 25.0	4.0 3.4	4.7 6.5	1.5	4.4	7.6	14.4
																9.1
Fall																
	1	Hat	1.2	2.1	4.0	2.1	1.2	3.3	15.0	34.8	12.7	3.8	1.4	4.7	10.8	3.0
	2	Hat	1.9	2.8	3.6	1.7	2.1	5.2	14.4	31.7	11.3	5.4	1.9	4.0	10.7	3.3

which the behavior of the prey coho salmon and hatchery steelhead varied significantly in the presence of the brook trout predators (Bugert and Bjomn 1991). It appears that either the brook trout were not effective as predators under the experimental conditions or that the prey we used had a low susceptibility to the effects of the predators due to their size. Predation rates during the spring and summer averaged three fish per predator (5.0%) over the ten day trial period.

In the fall the predation rate was significantly lower than during the previous two trials. The size attained by the hatchery fish by this time (83.3 mm) probably reduced the threat of predation by the predators we used.

Hatchery fish may be more susceptible than natural fish to predation due to their higher activity and aggressiveness. and lower use of cover habitat (Steward and Bjomn 1990; Swain and Riddell 1990). The hatchery chinook salmon in this study made the greatest use of pool surface waters and maintained aggressive behavior towards each other in the presence of predators. No natural fish were used for this study, so we can only speculate on the how the presence of hatchery fish would effect predation of natural fish. Kennedy and Strange (1986) reported that Atlantic salmon fry had higher survival and growth rates in streams in which the resident trout had been removed. Hillman and Mullan (1989) observed that natural chinook salmon tended to leave cover, and were subsequently preyed on by resident trout, when hatchery fish were present. Similarly, we observed that natural chinook salmon made less use of cover and greater use of the pool areas when hatchery fish were present and water temperatures were below 10°C (see section on size-density experiments). In the presence of predators, it would seem that this type of behavioral shift would increase the risk of predation on the natural fish. However. direct comparisons of predation on natural and hatchery chinook salmon will need to be made before conclusions can be drawn.

Chinook Salmon Juvenile Emigration Study.

Chinook salmon juveniles collected at the Lemhi River weir were tagged using passive integrated transponder (PIT) tags to estimate the minimum survival and travel times of downstream migrants from the Lemhi River to Lower Granite Dam. In the mornings, the fish to be tagged were moved to the tagging shed adjacent to the Lemhi weir and anesthetized using tricaine methansulphanate (MS-222). The PIT tag was injected into abdomen of the fish using a sterilized 12 gauge hypodermic needle, lengths and weights were recorded, and the fish were placed in a live box just upstream from the weir to recover. The tagged fish were generally released in the evening at the town of Lemhi, 1.6 km upstream from the weir, so that recaptures could be made the following morning. However, during the spring of 1993, the PIT tagged chinook salmon were released at three sites; the town of Leadore, about 94 km upstream from the Lemhi-Salmon River confluence, the Lemhi weir, and in the Lemhi River near its mouth. We initially released fish at the town of Salmon (the mouth of the Lemhi River), but this location was changed to the L-6 irrigation diversion, about 8 km upstream from the town of Salmon, after a remote detector was installed on the irrigation screen bypass tunnel. The three release sites were used to determine the differential travel time and survival associated with fish that must travel the length of the Lemhi River (from the Leadore release site) compared to those released at the weir and near the mouth of the river. Releases of fish were alternated daily among the three sites to reduce of effect of Lemhi River flow and irrigation diversion conditions on comparisons between sites.

We had hoped to PIT-tag 900 fish in the spring of 1993 (300 per release site), 500 in the summer and another 500 in the fall of 1993. However, only 404 chinook salmon were tagged in the spring and none in the summer due to the low number of fish moving downstream early in the year. A total of 801 chinook salmon were tagged in the fall of 1993.

Results and Discussion.

Of the 579 juvenile chinook salmon tagged and released at the Lemhi River weir in the fall of 1992, 72 (12.4%) were detected at Lower granite Dam from 14 April to 19 May 1993 (Figure 6). These fall migrants overwinter downstream from the Lemhi weir and continue on to ocean in the spring. The average time between their release at the Lemhi weir and detection at Lower Granite Dam was 206.4 days (sd = 9.1) (Figure 7). This compares to a detection rate of 17.1% and a travel time of 155.6 days for fish tagged the fall of 1991.

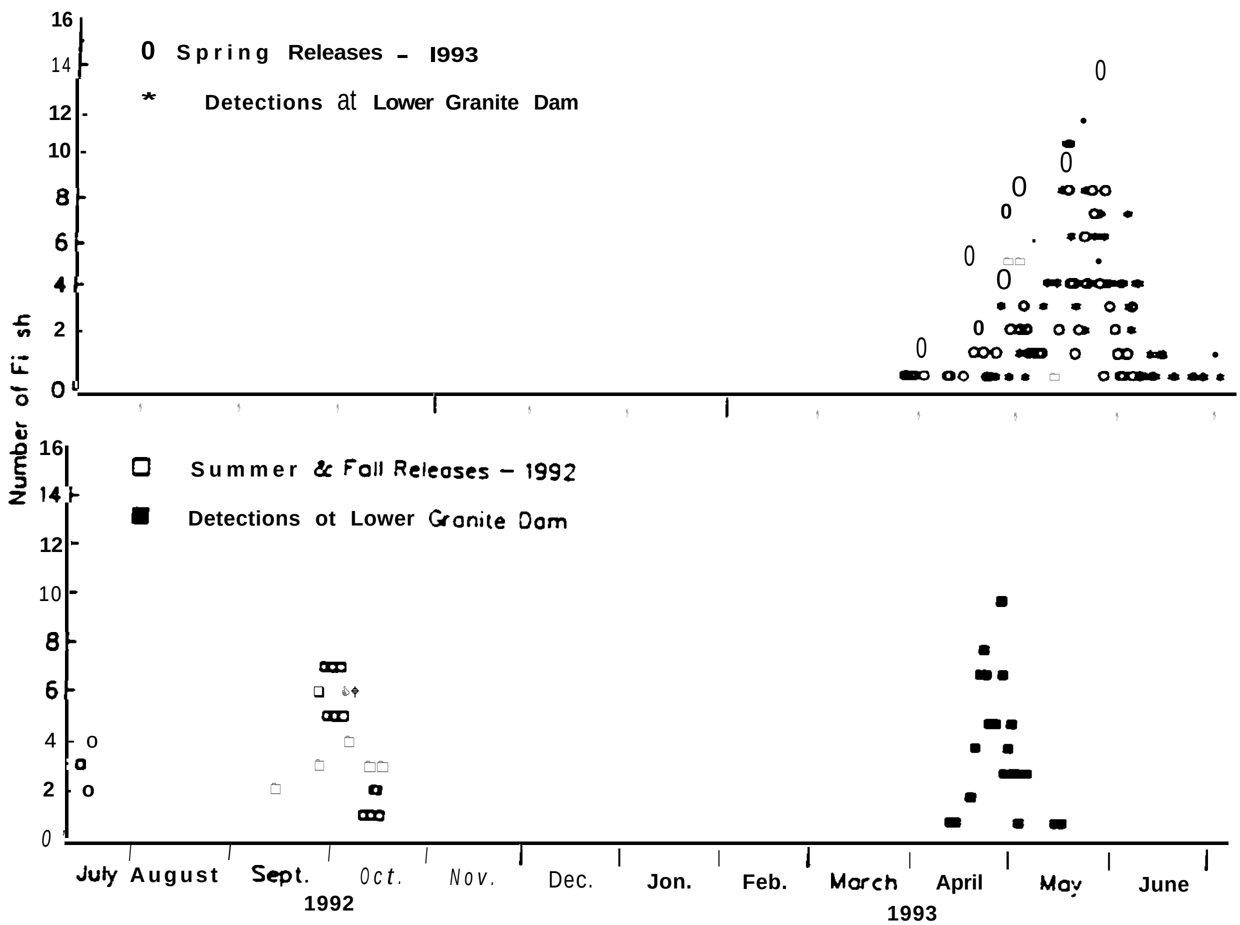

Figure 6. Detections of PIT tagged chinook salmon from the Lemhi River, and associated release times in the spring of 1993 and the summer and fall 1992.

Of the 404 chinook salmon PIT-tagged in the spring of 1993, 43 were released at the mouth of the Lemhi River, 78 were released at the L-6 diversion, 173 were released at the Lemhi weir. and 110 were released in the town of Leadore at the headwaters of the Lemhi

River. Eighty-nine, or 22.0%. of these fish were detected at Lower Granite Dam from 22 April until 3 July 1993 (Figure 6). Detections in 1992 were 11.2%. Lower Granite Dam

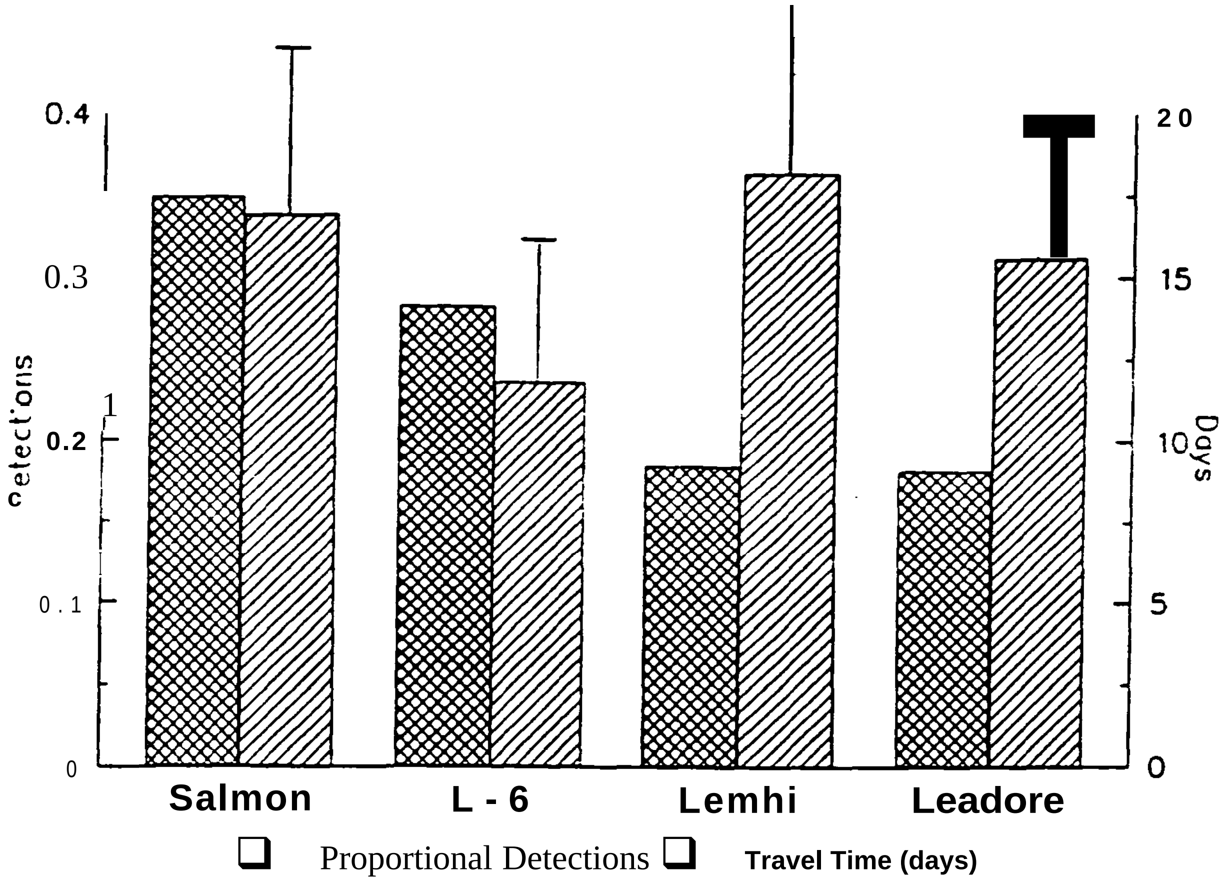

Figure 7. Proportional detections at Lower Granite Dam, and travel time for PIT tagged chinook salmon juveniles released at four locations in the Lemhi River in the spring of 1993. Bars represent one standard deviation.

detections from each release site were 15 (34.9%) from the mouth of the Lemhi River, 22 (28.2%) from the L-6 irrigation diversion, 32 (18.5%) from the Lemhi weir, and 20 (18.2%) from the Lemhi River headwaters, with average travel times of 16.9, 11.8, 18.2 and 15.6 days. respectively. Detections at Lower Granite Dam of fish released in the town of Leadore and from the Lemhi River weir were significantly lower than for fish released in Salmon and at the L-6 diversion (Chi-square. P < 0.01). Travel times from the four release sites were not significantly different. A remote PIT tag detector placed in the fish bypass tunnel at the L-6 irrigation diversion was used to determine travel times from the two upstream release sites. Of the 78 chinook salmon released 100 m upstream from the L-6 diversion, one-third were detected in an average time of 1.9 days (sd = 2.6). A total of 19.7% (34/173) of the fish released at the Lemhi River weir were detected at L-6 in an average time of 4.3 days (sd = 3.6), and 26.3 % (29/1 10) of the fish released from Leadore were detected in an average of 7.4 days (sd = 5.1).

As expected, the young-of-the-year chinook salmon tagged in the fall of 1992 had protracted travel times to Lower Granite Dam. These chinook salmon pre-smolts were emigrating from natal rearing areas to downstream over-wintering areas, where they held until the spring-time outmigration to the ocean. This pre-smolts emigration may be a response of the fish to the suitability and winter carry capacity of the natal rearing areas. The current low abundance of chinook salmon in the Lemhi River makes it unlikely that winter habitat is limiting.

We found no significant differences in the travel times of the fish from the four release sites to Lower Granite Dam. There was, however, lower survival for fish released at the Lemhi River weir and at the headwaters of the Lemhi River than for fish released at the two downstream sites. Indications are that there is a significant reduction of survival for fish traveling through the Lemhi River. but that the fish that did reach Lower Granite Dam were not significantly delayed by the added passage. Fish released just upstream from the L-6 diversion required an average of 1.9 days to find and pass through the bypass tunnel and return to the river. The large number of diversions on the Lemhi River (over 60) may have be related to the lower survival of fish passing down the river. The lower survival of fish released at upriver sites may be a function of the greater migration distance. For smolts released from Idaho hatcheries, there is a relationship between distance traveled and detections at Lower Granite Dam. More attention is needed in this area of study in order to identify specific sources of mortality and delay in the migration corridor.

Abundance of Chinook Salmon Downstream Migrants in the Lemhi River.

Downstream movement of chinook salmon juveniles in the Lemhi River was monitored using the downstream migrant trap located at the Lemhi River weir. The Lemhi River weir consists of removable metal racks angling 60° to the downstream flow (Figure 8). The downstream migrant trap, which was restarted the fall of 1991, is located along the west bank of the river at the downstream-most end of the weir (see Bjornn 1978). Under normal operating conditions the trap samples approximately 10% of the Lemhi River. During low water conditions, plastic sheeting material is placed over the weir racks to divert more water and fish through the trap. Fish entering the trap at the weir are guided by de-watering louvers to a perforated metal live box, where they are held until the trap is emptied. During sampling.

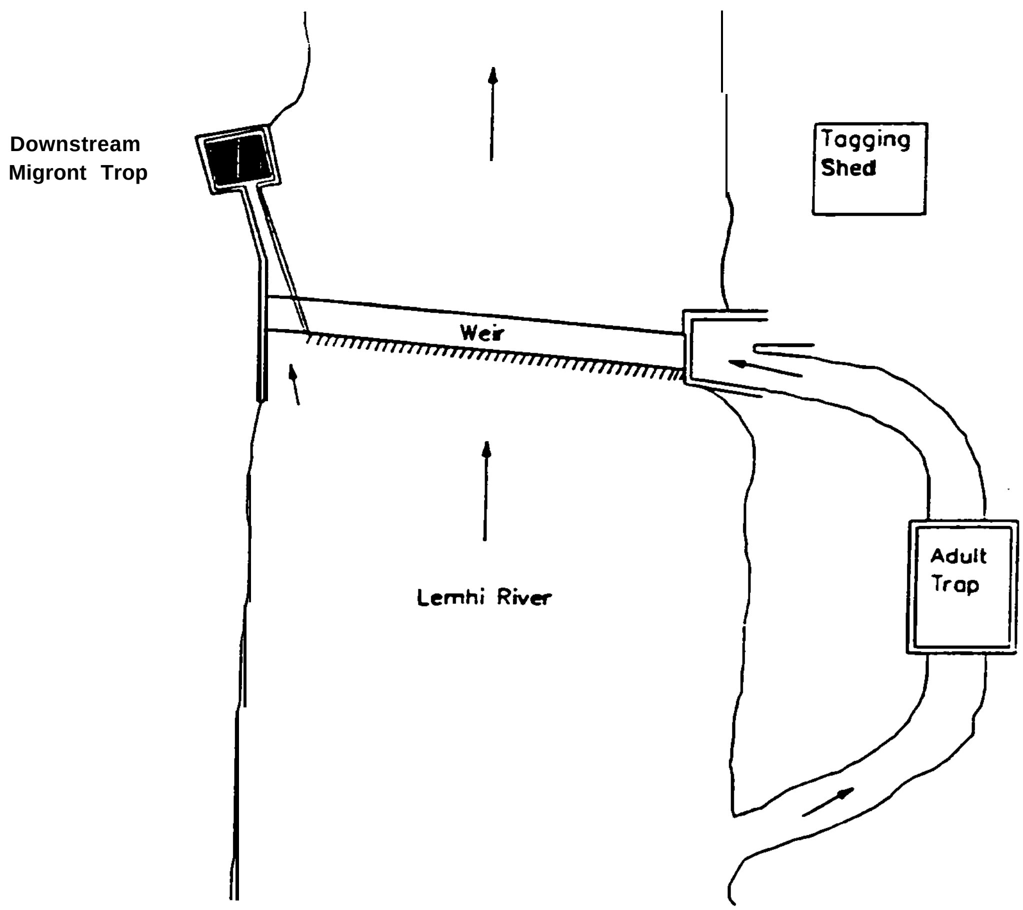

Figure 8. Plan of Lemhi River weir with downstream migrant and adult traps

the live box is raised and the fish become concentrated into a depression set into the solid bottom, from which the fish can be dip netted out.

The downstream migrant trap was operated continuously from 28 February unti1 6 . December in 1993. The trap was checked twice a day, in the morning between 0800 and 0900, and in the evening between 1700 and 1800. During each sampling we recorded the number and lengths of the chinook salmon and trout collected, the number of other fish species in the trap, the air and water temperatures and water depth.

Data Collection and Analpis.

Periodically through the year PIT-tagged chinook salmon were released 1.6 km upstream from the weir to determine the sampiing efficiency of the trap. Population estimates were made using the equation developed by Chapman (195 1) as discussed by Ricker (1975), where M is the number of fish marked at time t. C is the number of fish caught at time t + 1. R is the number of marked fish recaptured at t + 1 and N is the estimated number of fish moving past the weir at t + 1.

$$N = \frac{(M + 1)(C + 1)}{(R + 1)} \quad [1]$$

and

$$V(N) = \frac{M2(C - R)}{(C + 1)(R + 1)}, \quad [2]$$

Ricker (1975) suggests that R should be at least three to reduce bias. For our analysis. days in which recaptures totaled less than three were grouped so that R was always three or more. The number of fish moving during these groups of days was then estimated and summed to determine the total movement of chinook salmon past the Lemhi River weir.

Results and Discussion.

During the fall of 1992, a total of 1,381 young-of-the-year (YOY) (brood year 1991) chinook salmon were collected at the Lemhi River weir, and the total movement of YOY . chinook salmon past the Lemhi River weir was estimated to be 13.799 fish. The capture efficiency of the trap averaged 10.9% during the fall.

In 1993 the downstream migrant trap was operated from 28 February until 6 December. During this period, a total of 2,048 YOY (brood year 1992) and 587 yearlings (brood year 1991) chinook salmon were collected. There were three distinct migration periods coinciding with the spring, summer and fall seasons (Figure 9).

In the spring of 1993 (28 February - 31 May) a total of 23 YOY and 468 yearling chinook salmon were collected. Estimated movement during the spring was 532 YOY (95% C.I. = 134-859), and 4,952 yearlings (I ,266-7,208). This was the highest movement of yearling chinook salmon during 1993. The number of chinook salmon collected during the summer of 1993 (1 June - 3 1 August) totaled 77 YOY and 61 yearlings. The summer movement was estimated to be 122 YOY (49-231) and 94 yearlings (36-170). A large portion of the YOY were collected during the last part of August (Figure 9). The peak number of chinook salmon collected at the Lemhi weir occurred during the fall of 1993 (1 September - 6 December). During this period a total of 1,948 YOY and 58 yearling chinook salmon were collected and the estimated movement was 8,199 YOY (5,283-17,077) and 112 yearlings (53-220). Most of the yearlings were precocious males collected during the latter parts of the spawning season in late September. The total number of chinook salmon estimated to have moved downstream while the trap was operating was 8,835 (95 % C.I. = 5,466-18,167) YOY and 5,157 (1.355-7,598) yearlings. The capture efficiency of the trap for entire 1993 field season averaged 10.0%.

The number of chinook salmon reported to be moving downstream in 1993 are

Appendix I. Continued.

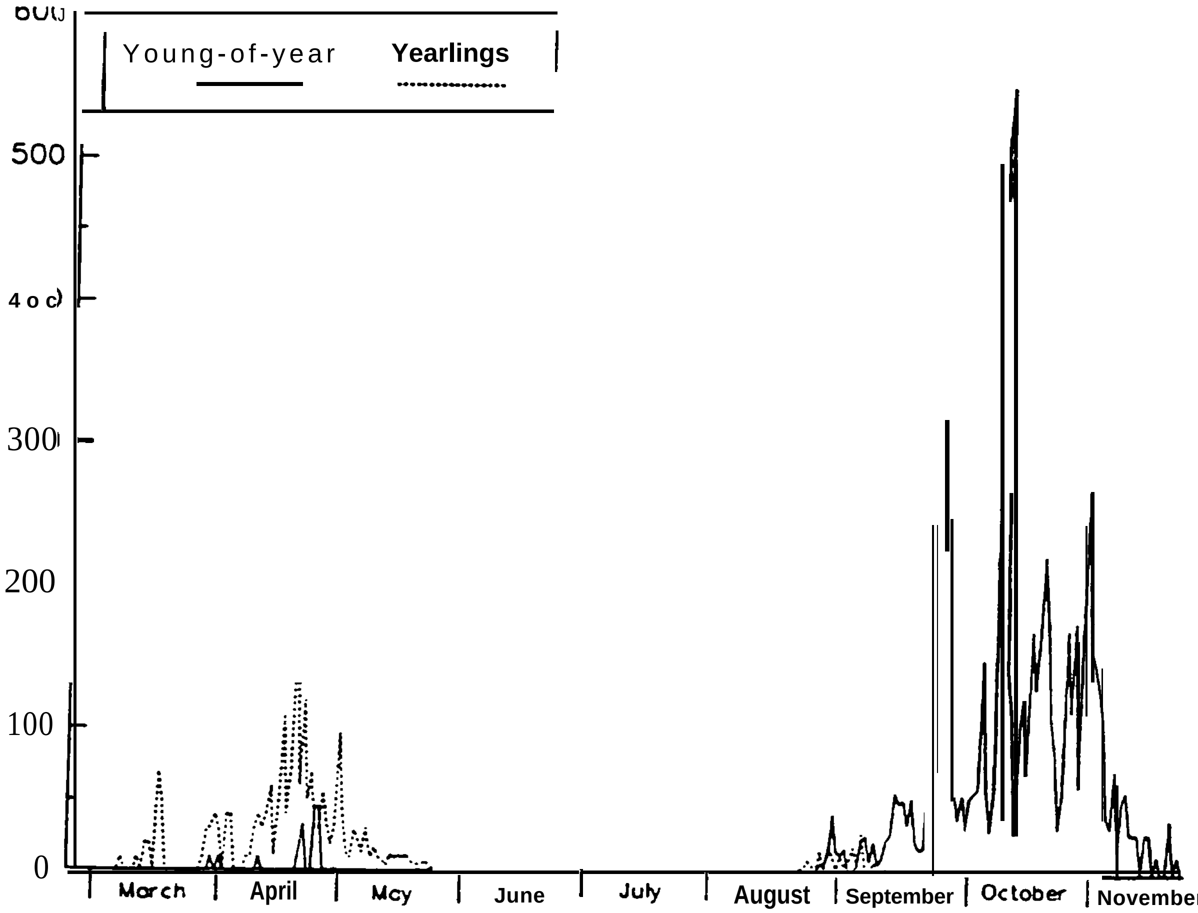

Figure 9. Estimated movement of chinook salmon young-of-year and yearlings past the Lemhi River weir, 1993.

significantly lower than during 1992 and from 20-30 years previous (Bjomn 1978). During the period from 1963 until 1974 Bjomn (1978) reported that the estimated total chinook salmon moving past the Lemhi River weir ranged from 0.3 to 1.2 million fish. The pattern of movement we saw in 1992-93 also differed from that reported by Bjomn (1978), with the majority of chinook salmon moving downstream as presmolts in the fall of 1993 rather than newly emergent fry as in 1963-74. The recapture rates we observed in 1992-93 ranged from 10.0 to 18.5%, higher than the 1.7 to 5.2% reported by Bjomn (1978). The discrepancy is probably due to more efficient trap design in 1991-93. We altered the structure of the Lemhi weir and used plastic sheeting material over the weir racks to divert more water and fish into the trap.

Adult Salmon Movement in the Lemhi River.

The upstream migrant trap at the Lemhi River weir was repaired and put into operation on 5 August 1992. Returning adult salmon and steelhead reaching the Lemhi weir are diverted by the metal racks to the adult trap via a side channel in the east bank of the river (Figure 8). The fish pass over a finger weir to enter the trap where they remain until the false floor is raised and they are allowed to swim out the exit chute at the head of the trap. As the fish leave, they are netted so that their sex and fork lengths can be recorded. The fish are then released and continue to swim upstream for approximately 100 m to where the side-channel re-joins the river.

The adult trap at the Lemhi weir was operating by 1 March 1993. In 1993 a total of 54 adult chinook salmon were passed through the trap between 18 June and 28 August, 22 males and 32 females. Most (80%) of the females we counted in 1993 were large three-ocean fish, and only two of the males were jacks. Redd counts for the Lemhi River were conducted by IDFG Salmon Office personnel*, ground counts and helicopter counts were made. A total of 36 redds was identified in the section of river upstream from the Lemhi weir during the fall of 1993. In 1992, 33 adult chinook salmon and 6 redds were counted for the Lemhi River upstream from the weir.

Chinook Salmon Collections for Genetic Analysis.

During 1993, 586 naturally-produced chinook salmon pre-smolts and 200 hatchery-produced smolts were collected from 12 streams and two hatcheries to establish a genetic database of these stocks (Table 7). The database will be used to monitor possible shifts in the genetic makeup of non-target stocks following supplementation as identified in the ISS study plan (Bowles and Leitzinger 1991). Most fish were collected using a backpack electroshocker at selected sites in each stream or river. The collection sites were spaced at least 0.5 km apart and no more than 11 fish were collected from a site to reduce the chance that the fish were progeny from the same redd. Baited minnow traps were used to collected the chinook salmon

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